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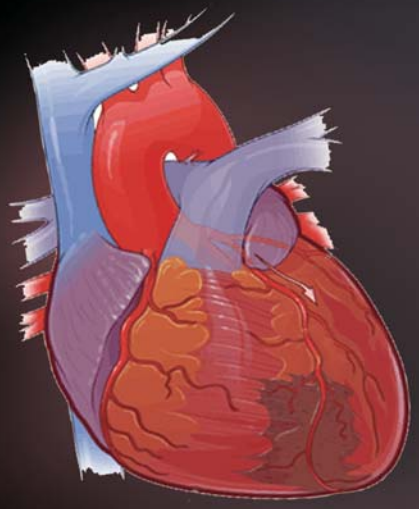
MESSENGER Reveals Unseen Face of Mercury



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

A Messenger's Messenger

After travelling more than 3.5 billion kilometres and three and a half years, the *MESSENGER* spacecraft of NASA made its first flyby of Mercury on 14 January 2008, and beamed back a stream of surprises. The name comes from "*ME*rcury *S*urface, *S*pace *EN*vironment, *GE*ochemistry, and *R*anging," highlighting the project's broad range of scientific goals. The planet Mercury itself is named after the mythological messenger of the gods! The images sent by the spacecraft conclusively showed that the planet resembles the Moon much less than many had previously thought, and has many features unique to this innermost world. Incidentally, this was only the second mission to Mercury after 34 years. Earlier, *Mariner-10* spacecraft of NASA flew by the planet three times in 1974 and 1975. Much of what we knew about Mercury before the recent flyby of *MESSENGER* was based on data from these flybys, even though they provided pictures of only about 45 per cent of the planet's surface.

Indeed, of all the planets in our solar system, Mercury is the strangest. It is invisible to the naked eye except at times of greatest elongation, that is, when it is at its maximum angular distance from the Sun. By virtue of its rapid motion, Mercury seems to be playing hide and seek with us. It never goes more than 28 degrees away from the Sun, and is never 2 hours before or behind it. Even on the day of greatest elongation (28 degrees), it is just on the horizon as soon as the night is sufficiently advanced for it to be seen with the naked eye. Slightest mist on the horizon and one cannot observe it! These are some of the inherent difficulties in observing Mercury and this is why it has been far less studied than the other planets. Indeed, Copernicus never even managed to see it from his observatory at Frauenburg in Poland!

Mercury is the innermost and the smallest planet in the solar system orbiting the Sun in a highly elliptical orbit once every 88 days. Transits of Mercury are much more frequent than those of Venus – on an average 13 in each century. It has no natural satellites, and no substantial atmosphere. The surface temperatures on Mercury range from about -180°C to 430°C. The regions facing the Sun are the hottest and the bottoms of the craters near its poles are the coldest. Being an inner planet, it also shows phases like Venus.

But, what makes the planet Mercury enigmatic? It has a face like the Moon that is heavily cratered. What is interesting is the fact that it is an exceptionally dense planet, suggesting that it has a huge metallic core – mainly iron, which accounts for more than 40 per cent of the planet's volume. This is a gigantic proportion compared to Earth's core, which fills just 17 per cent of its interior. Its origin is one of the greatest mysteries of Mercury. While most of the major planets go around the Sun more or less in the same plane, Mercury's orbit is tilted at 7 degrees. While Earth's orbit is nearly circular, Mercury prefers an ellipse. What is more, it even has a magnetic field, though only 1 per cent as strong as that of the Earth.

Even Einstein had an affair with Mercury. The planet's peculiar motion could not be explained by Newton's theory of gravitation alone. The puzzle was finally solved when Einstein applied his General Theory of Relativity that became the convincing evidence of the theory. Now astronomers believe that Mercury holds another secret – how the solar system itself was formed. During the flyby of 14 January 2008, *MESSENGER* found many differences between the surface features of the Moon and Mercury. Unlike the Moon, Mercury has huge cliffs with structures snaking hundreds of kilometres across the planet's face. The data beamed back revealed impact craters that appear very different from lunar craters. One particularly curious crater has been dubbed "The Spider"! A formation like this has been observed for the first time on Mercury, and nothing like it has been observed on the Moon. It lies in the middle of a huge impact crater called the Caloris basin and consists of more than 100 narrow, flat-floored troughs radiating from a complex central region. Incidentally, *Mariner-10* had seen only a part of this basin. *MESSENGER* has shown the basin's fullest extent. Caloris is one of the largest impact craters in the solar system and perhaps as large as 1,550 kilometres from rim to rim!

Next, *MESSENGER* found Mercury's magnetic field different from what *Mariner-10* had seen. On 14

Contd. on page... 19

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Thiruvenkata Rajendra Seshadri

A Scientist of Unassailable Integrity

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

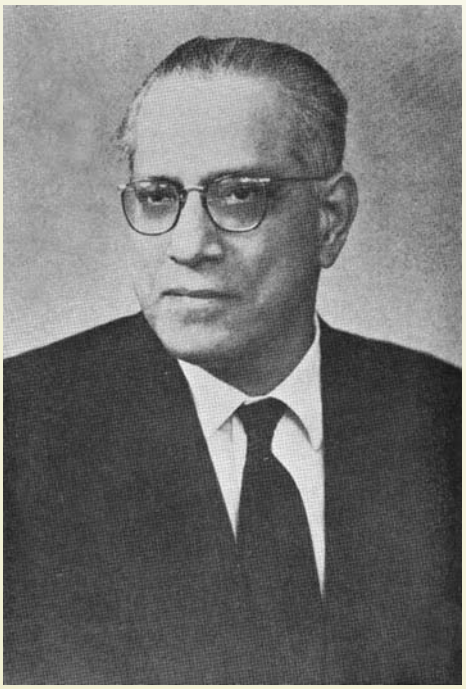
"Money and materials alone do not secure good research; they are only adjuncts and it is the human element behind them that does. Leadership in this context is of utmost importance. Not only in war, not only in big business and industry, but also in research there is what is known as "strategy". We have all appreciated great generals who with small armies and limited weapons have overpowered larger and better equipped and adversaries. Similarly with small resources great men have built up large industries. We can ignore leadership in the field of scientific research only at the cost of the nation's "security and prosperity"

T.R. Seshadri

Tiruvenkata Rajendra Seshadri was one of the most accomplished chemists of India. He built up one of the finest schools on chemistry of natural products. His own research contributions to chemistry were very significant. The work of Seshadri and his group on natural products can be grouped in to four areas, viz., structure elucidations; synthesis and synthetic methods; stereochemistry; and biogenetic theory. Seshadri trained 160 PhD students and published more than 1,000 research papers. Among the compounds whose structures were elucidated were: Gossytrin and related pigments of cotton and hibiscus flowers, pedicinin, pedicellic acid and related compounds, mangiferin, dalbergin, latifolin, ferreirin and homoferreirin, pongamol, karanjin, auranetin, prudomestin, nepitrin, pedaliin, cupressuflavone, thelephoric acid, virensic acid, tingenone, enhydrin, santalin, and alpha terthienyl methanol,

The synthetic methods developed by Seshadri and his group include: selective O-methylation and demethylation, C-methylation, C-prenylation, nuclear oxidation (removal of a hydroxyl group), and nuclear reduction. They also carried out the total synthesis of the following compounds: gossypetin, quecetagetin, khellin, pterocarpin, rotenoids, cyanomaclurin, pedaletin, damanacanthal and related anthraquinones.

Seshadri was born on 3 February 1900 in Kulitalai, a small town situated on the banks of the river Kaveri near Tiruchirapalli. He was the third of the five sons of his parents Thiruvengadatha Iyengar and Namagiri Ammal. His father was a teacher in a local school. He had his school education in the temple towns of Srirangam and Tiruchirapalli. In school,



T R Seshadri

he was much influenced by his teachers, who instilled in him 'a sense of duty, obligation to society, love of humanity and thirst for knowledge.' In 1917, Seshadri joined the Presidency College to study the BSc (Honours) course in chemistry. While studying at the Presidency College he stayed at Sri Ramakrishna Mission's students' home where he gained spiritual training from the Mission monks. Among the teachers of the Presidency College who had lasting influence on his life and career was P. A. Narayana Iyer.

After obtaining the Honours degree in chemistry of the University of Madras, Seshadri worked for the Ramakrishna Mission for a year. Later he started doing research in the Chemistry Department of Presidency College as a University research scholar. His research supervisor was B. B. Dey, who was then heading the department. Seshadri's work with Dey on the synthesis of quinolino–pyrones earned him two prizes from the University of Madras – the Sir William Wedderburn Prize and the Curzon Prize. In 1927, Seshadri was selected for a scholarship awarded by the Government of Madras for studying abroad. The scholarship enabled him to visit England, where he worked with Sir Robert Robinson at Manchester University on new anti-malarial drugs and synthesis of anthocyanins. Based on his research work he obtained a PhD degree of the Manchester University in 1929.

Robinson was much impressed by Seshadri's abilities. In his message on Seshadri's 60th birthday he wrote: "Even if Professor Seshadri were known to me only as an author of original memoirs in chemical journals I would be gratified to have this opportunity to add my tribute to

his fertility of ideas, his technical skill in execution and his qualities of energetic drive and wise planning. His original researches have indeed given him worldwide recognition and he is unsurpassed in the experimental survey of the groups of natural products on which he has concentrated his attention. But, to me, he his no mere name in the literature. I have enjoyed the inestimable privilege of following his development from the beginning…We do homage to a scientist of unassailable integrity, a brilliant and devoted and a most generous friend."

Brfore returning to India, Seshadri visited some important research centres in Europe. He worked for some months in the laboratory of Fritz Pregl (1860-1930) at Gratz, Austria to learn the techniques of organic microanalysis. Pregl is regarded as the father of the technique of organic microanalysis, which drastically reduced the quantity of organic substances required for analysis. Before Pregl the elemental analysis of organic compounds was unreliable and required a sample of about 0.5 g. With Pregl's techniques it was possible to work out with a sample of 2.5 mg. Pregl's techniques led to the rapid progress in the chemistry of natural products. Pregl was awarded Nobel Prize in Chemistry in 1923. It is interesting to note that Pregl was unusual among Nobel Prize winners in that the award was not given for a discovery but for 'modifying and improving existing methods.' From Pregl's laboratory, Seshadri went to the laboratory of Geroge Barger, a Fellow of Royal Society, in Glasgow. Seshadri spent about eight months in Barger's laboratory, and worked on the chemistry of retrosine. Seshadri also spent a short period in the laboratory of Cameron, Chief Agricultural Chemist to the county of Fife. Here Seshadri got himself familarised with the methods of agricultural chemistry.

Seshadri returned to India in 1930. He first joined the Madras University as a Research Fellow. But after some months he joined the Agricultural College and Research Institute as a soil analyst. There was little scope for undertaking fundamental research in this institute. After three years working as a soil analyst, Seshadri joined Andhra University at Waltair as senior lecturer and head of the newly created Chemistry Department. It was a great challenge, the task before him was to build a university department from scratch. He had to build new laboratories and equip them. Courses of study had to be framed. Seshadri built up an excellent department. While he was busy in building up his laboratories he continued his research. It was not easy. He had to rush on a bicycle to the Biochemistry Department of the Andhra Medical College at Visakhapatnam, located about 5 kilometres away. In 1934, Seshadri was appointed reader. In 1937, Seshadri became professor and was also given the responsibility of looking after the University Department of Chemical Technology. In the same year Seshadri laid the foundation of the Department of Pharmaceutical Sciences of Andhra University.

The Second World War disrupted Seshadri's work. In those days Indian research laboratories totally depended on Europe for chemicals and scientific goods. The war made these scarce. Then there were other war-time restrictions. The result was severe curtailment of laboratory work. The bombardment of the port at Visakhapatnam, which was just about 6 km away from the University Campus, by the Japanese led to the evacuation of the entire town of Visakhapatnam including the University Campus at Waltair. The University buildings came under the control of the Defence Department. The laboratories built by Seshadri were dismantled for converting into military bases. The teaching departments and administrative offices were shifted to Guntur and accommodated in rented premises or temporarily built sheds. The Chemistry Department was shifted to Chennai (then Madras) at the beginning of the academic year 1943-44, where class work was done in the Chemistry Department of Presidency College and biochemical research laboratories of Madras University. Some research work also started. All the departments of Andhra University shifted back to Waltair in the beginning of the academic year 1946-47. Seshadri had to rebuild his laboratories, which had been completely dismantled to meet the requirement of the war. It was not an easy task in the post-war period. Seshadri's zeal for research was too great to be diluted by the adverse circumstances. He started re-building his research laboratories so that research work could be resumed and succeeded in doing so.

Fritz Pregl

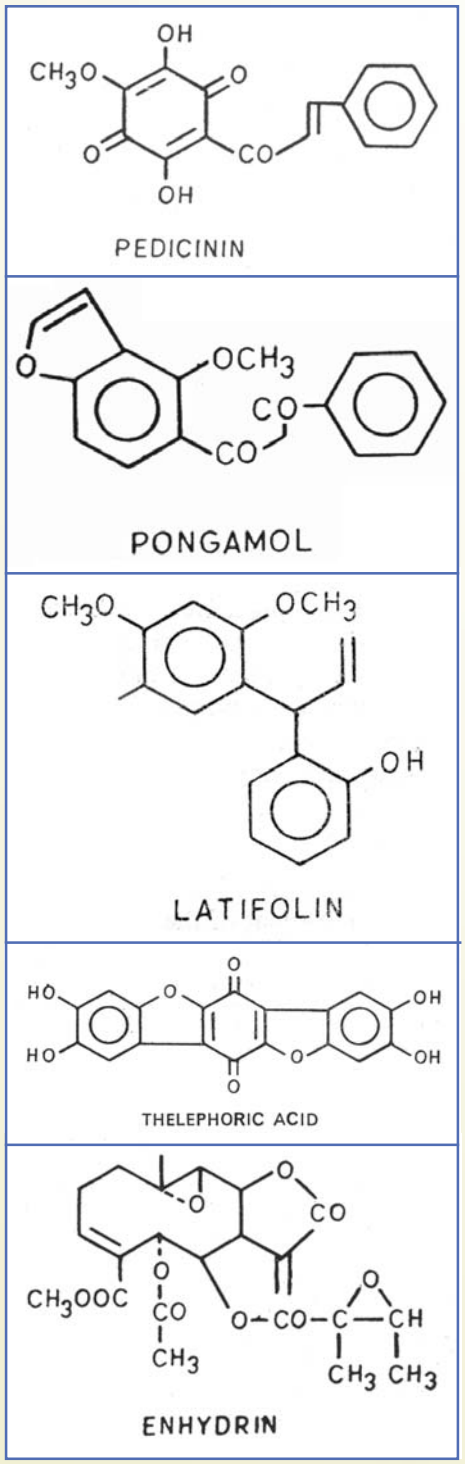
Robert Robinson

In 1949, Seshadri was invited to head the Chemistry Department of the Delhi University by its Vice Chancellor Sir Maurice Gwyer. For Seshadri it was a

difficult decision because by then he had built up an active school of teaching and research at Waltair. However, finally he decided to take up the new challenge. In Delhi, Seshadri started an active research centre on natural products. In 1962, the Department of Chemistry of Delhi University was selected by the University Grants Commission as a Centre for Advanced Study of Natural Products. Seshadri became its first Director. After his retirement in 1965, the University of Delhi appointed him as its first-ever Emeritus Professor. It enabled him to continue his research.

Seshadri was a great teacher. He inspired many young researchers. He helped many students in many ways. N. R. Krishnaswamy wrote: "However, the one thing he cherished most was the affection of his students. He helped them in every way including giving financial assistance in times of need. To remain with his students, he declined the post of the Chairman of the University Grants Commission. His students reciprocated by bringing out commemorative volumes on his 60th, 65th, 70th and 75th birthdays. There are also endowments to perpetuate his memory. Even after retirement in 1965, Seshadri continued to teach and guide research and was always available to his students. He would sit through every student seminar and critically evaluate the presentation. His research school at Delhi consisted of half a dozen laboratories in three different buildings in which more than 25 students used to work at a time. He had the time and stamina to visit each one of them, at least four times a day, and to spend several minutes with each and every student."

Seshadri's comments on Indian Science Congress is still relevant. He said: "There is need, therefore, for a reorientation of function for this large Science Congress. Such a change has taken place with similar science organisations in other countries also; for example, the British Association for the Advancement of Science, on whose model the Indian science Congress was founded, is now the major organisation for contact between British scientists and the British public. The annual meetings of the Association are arranged under the joint auspices of a University and a City-Council and the responsibilities are equally divided between the Mayor and the Vice-Chancellor. It is an occasion for many special functions both in the university and in the city. I feel that we should also take effective steps to make this Science Congress more and more effective as liaison between scientists and the public. In an age of science this becomes an essential activity for a national body. Our annual meetings should be used for discussing more fully major developments in science and their application to national welfare; all activities, which would be duplication of the work of specialist societies could be minimised. More emphasis should be placed on science education of the youth – school and college students. Special programmes should be arranged for them, e.g., special lectures, educational films and exhibitions."



Some of the compounds synthesised by T. R. Seshadri and his group

In 1960, Seshadri was elected a Fellow of the Royal Society of London. The Government of India conferred on him the *Padma Bhushan* (1963). He was elected General President of the Indian Science Congress Association. He was also the President of the Indian Chemical Society and Indian Pharmaceutical Congress. He served on the editorial boards of the prestigious international journal, *Tetrahedron* and *Phytochemistry*.

Seshadri's contribution to the development of chemistry in India was very significant. However, the last few years of his life were not happy ones. To quote: "The last few years of Professor Seshadri's life make a sad reading. In the forties he had declined offers of positions of prestige and pelf, declaring that he would be only a university teacher. Later in 1960, he declined the offer of the office of Chairman of the University Grants Commission. He had hoped that chemistry would secure for him the resources to live a simple life. In 1965, he donated his personal library, the entire collection of books and journals of three decades, to Delhi University Chemistry Department and continued to donate all the journals that he received subsequently also, hoping that he could work peacefully in the Department to the end of his life. In 1972, new rules and regulations of the Delhi University prevented him from receiving honoraria or remuneration from any quarters, thus bringing financial

(Contd. on page...23)

Marvels of Gene Targeting

Biman Basu
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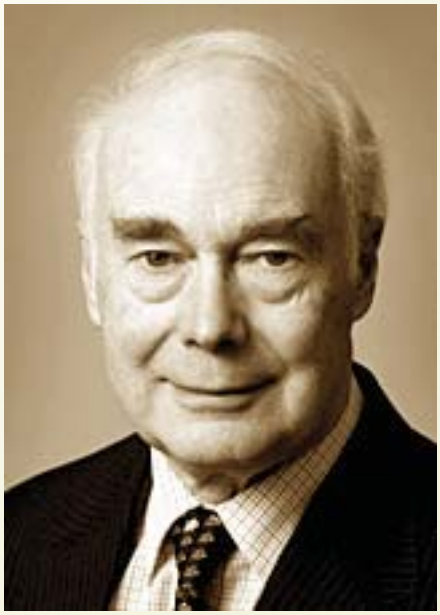
One of the most significant developments in the post-genetic engineering era of modern biology has been the role of the mouse as an experimental animal of choice for the entire spectrum of research: from basic science to the development of new therapies in biomedicine. Mice have been likened to 'pocket-sized' humans because they have the same organs and their genes are about 95 percent identical in sequence to humans. Scientists have developed more than 500 different mouse models of human ailments, including those affecting the heart and central nervous system, as well as diabetes, cancer and cystic fibrosis. And all this has been possible thanks to the path-breaking discoveries of three of biologists – Mario Capecchi of the Howard Hughes Medical Institute at the University of Utah, USA, Sir Martin Evans of Cardiff University, UK, and Oliver Smithies of the University of North Carolina, USA – who shared the 2007 Nobel Prize for Physiology or Medicine.

Capecchi Mario

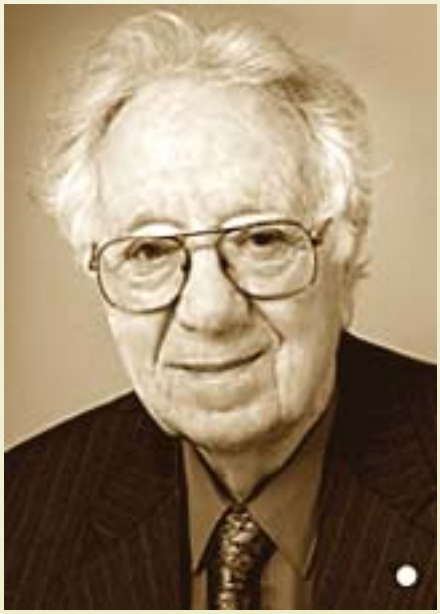
The three Nobel laureates made a series of ground-breaking discoveries concerning embryonic stem cells and DNA recombination in mammals. Their research has resulted in one of the greatest advances in biological science in recent years, and one that many scientists make use of daily. Their discoveries led to the creation of an immensely powerful technology referred to as 'gene targeting' in mice, which is now being applied to virtually all areas of biomedicine – from basic research to the development of new therapies. Gene targeting is a way of altering gene structure and hence function in animals, which provides a direct way to investigate the role of particular genes. This work also led to the development of mouse 'models' of human disease and is widely used to study the function of genes in both disease and in normal biology. It is also a basis for gene therapy – correcting faulty genes to treat disease.



Sir Martin Evans

Gene targeting technology can inactivate, or knock out, single genes to study development of the embryo, aging and normal physiology. So far, more than 10,000 mouse genes, or about half of those in the mammalian genome, have been knocked out, and ongoing international efforts are likely to make knockout mice for all genes available within the near future. Gene targeting has helped decipher the roles of many genes in mammalian foetal and organ development to unmask secrets of normal biological events.

The technique used by the Nobel laureates exploits a natural biological phenomenon called 'homologous recombination', which appears to have been conserved throughout evolution.



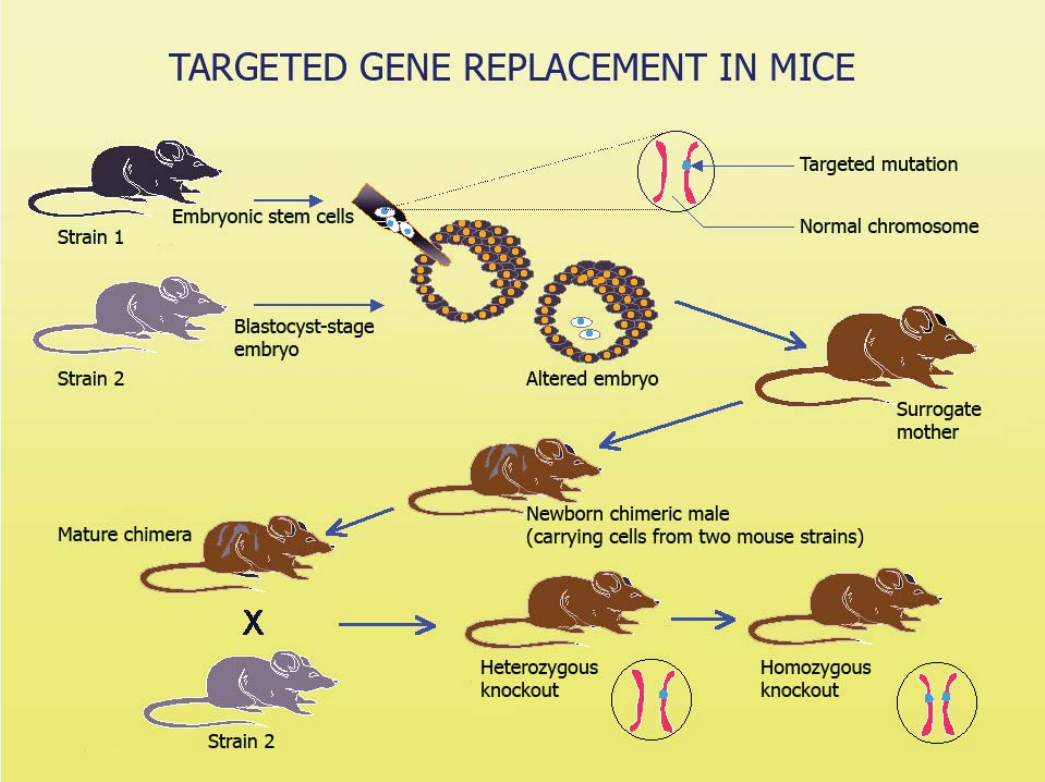
Oliver Smithies

The American molecular biologist Joshua Lederberg had demonstrated this in bacteria about half a century ago and won the Nobel Prize in 1958

for his work. Genetic information about development and body functions is contained in the DNA, which is packaged in the chromosomes that occur in pairs, one inherited from paternal DNA and the other from maternal DNA. The natural process of homologous recombination allows exchange of DNA sequences within such chromosome pairs that is responsible for genetic variation in the population.

In the 1980s, Capecchi and Smithies were seeking ways to specifically modify the mammalian genome – the former to insert new genes into cells and the latter to correct defective disease-causing genes. Both, independent of each other, struck upon the idea that homologous recombination could be exploited to introduce short DNA sequences into the chromosomes of mouse cells cultured in the laboratory. Finally they were able to develop precise methods for changing desired genes one by one. These discoveries led to the development of deleting, or 'knocking out', genes to discover their function. For example, if knocking out a gene made a little finger disappear, then that gene is important for making little fingers.

Evans laid the groundwork for making so-called 'knockout mice' when he discovered that days-old embryos are made up of super-powerful cells later dubbed 'embryonic stem cells'. Each one of these cells has the power to give rise to all the cells and tissues in an animal. Evans and colleagues later figured out how to genetically manipulate these cells and implant the embryos back into a female mouse, which gave birth to genetically altered offspring. Evans applied gene targeting to develop mouse models for the inherited human disease cystic fibrosis and has used these models to study disease mechanisms and to test the effects of gene therapy. Gene targeting in mice has today pervaded all fields of biomedicine and its impact on the understanding of gene function and its benefits to mankind will continue to increase over many years to come.



Knockout mice

Mario Capecchi was born in the Italian city of Verona on 6 October 1937. After a dismal childhood he moved to USA in 1946 and graduated from George School, in Bucks County, Pennsylvania, in 1956. He received his BS in chemistry and physics in 1961 from Antioch College in Ohio. Capecchi came to MIT as a graduate student intending to study physics and mathematics, but during the course of his studies, he became interested in molecular biology. He subsequently moved to Harvard to join the lab of James D. Watson, and received his PhD in biophysics in 1967 from Harvard University. In 1969 he became an Assistant Professor in the Department of Biochemistry at Harvard Medical School. He was promoted to Associate Professor in 1971. In 1973 he joined the faculty at the University of Utah. Since 1988 Capecchi has also been an investigator of the Howard Hughes Medical Institute.

Martin Evans was born at Stroud, Gloucestershire, England, on 1 January 1941. He graduated from Christ's College, University of Cambridge in 1963 and received his PhD from University College London in 1969. From 1966 to 1978 he was a lecturer at University College London and from 1978 to 1999 he taught at the Department of Genetics, University of Cambridge. At present he is Professor of Mammalian Genetics and Director of the School of Biosciences, Cardiff University.

Oliver Smithies was born in Halifax, West Yorkshire, England on 23 June 1925. He did his BA in 1946 and then earned a second bachelor's degree in chemistry. He received a MA 1951 and a DPhil in Biochemistry in 1951 at Balliol College, Oxford. From 1953 to 1960, Smithies worked in the Connaught Medical Research Laboratory, University of Toronto, Canada before joining the University of Wisconsin-Madison, USA as Professor of Genetics and Medical Genetics, a post he held from 1960 to 1988. Since 1988, Smithies has been designated an Excellence Professor of Pathology and Laboratory Medicine at the University of North Carolina at Chapel Hill. ■

All You Want To Know About – Ankylosing spondylitis

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

Ankylosing spondylitis is a persistent inflammatory disease of the spinal column and the pelvis that causes stiffening of the affected joints. While the spine takes

the maximum damage, the sacro-iliac joints at the back of the pelvis and the hip joints are also often affected. If the spine is severely diseased, new bone grows between the vertebrae, which eventually fuse together. This leads to such a severe hardening and stiffness of the spine that it begins to bear a striking resemblance to a bamboo stick.

The condition is much more common in men than in women. Usually, the disease begins in late adolescence or early adulthood, and in some families, it runs as a familial disease.

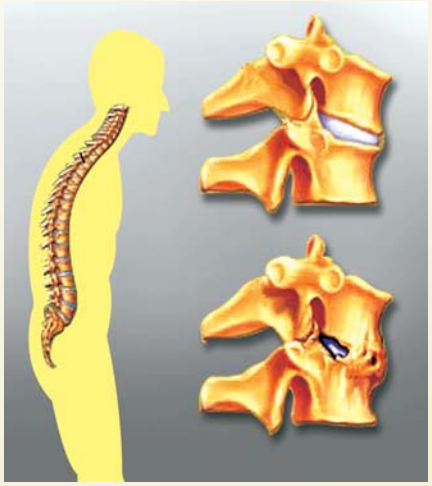
Causative factors

The cause of ankylosing spondylitis is unknown, but about 90 per cent affected people have a particular antigen (a substance that is capable of stimulating an immune response in the body) called HLA-B27 on the surface of most cells. This antigen is inherited. Most people with HLA-B27 do not develop the disease, but its presence predisposes them to develop the disease. A bacterial infection probably triggers the condition by fooling the immune system of the body to strike against its own tissues.

Symptoms

Classically, the disease appears in late adolescence or early adulthood and develops gradually over a period of months or years. The main symptoms include lower back pain and stiffness that may be worse in the morning and improve with activity. The sufferer may also have pain in other joints, such as the hips, knees, and shoulders, and pain and tenderness in the heels. At the same time, the person may feel tired and suffer mild fever and weight loss.

The disease can distort the spine and produce a stoop. In some people, due to widespread inflammation tissues other than the joints, such as eyes may also be affected. Some people also develop respiratory difficulties due to restriction on expansion of the chest.



Diagnosis

The first suggestion of ankylosing spondylitis relates to the pattern of symptoms. Your doctor may suspect the diagnosis on that basis and ask for X-ray of the spine and sacro-iliac joints to look for evidence of fusion in these joints. You may also be asked to undergo blood tests including HLA-B27 antigen, ESR, blood counts and others that look for evidence of inflammation.

Treatment

Treatment of ankylosing spondylitis is aimed at relieving the symptoms and preventing the development of spinal deformity. You may be prescribed a non-steroidal anti-inflammatory drug (NSAIDs) like indomethacin to control pain and inflammation. At the same time, you must also begin on an active exercise programme under the care of a physiatrist and a physiotherapist. Breathing exercises, and daily exercises to help improve your posture, strengthen the back muscles and prevent deformities of the spine must make an essential part of your routine.

To relieve pain, other pain-relief measures such as hot fomentation with wet packs, hot baths, sauna and massage may also be usefully employed. Some doctors also prefer to treat with intravenous corticosteroids, followed by oral steroids tapered over a period of weeks or months, to good relief.

You may also benefit from regular physical activity, such as swimming, which may help to relieve the pain and stiffness.

Surgery may also be useful if a joint such as a hip is affected. A total hip replacement can restore good function to the joint and relieve the deformity and disability.

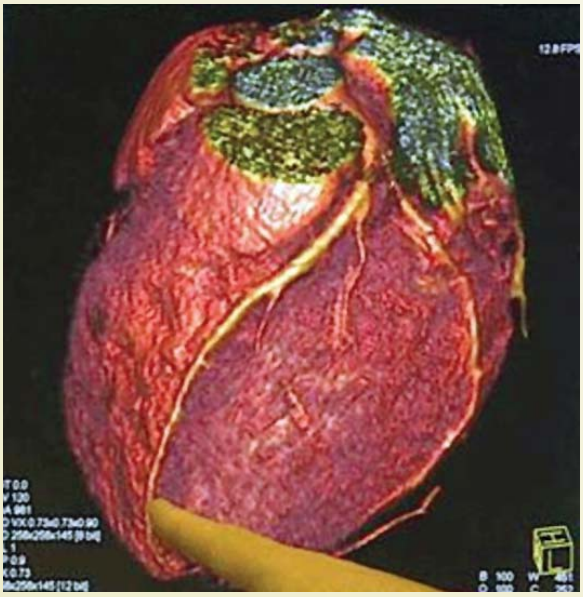
Although ankylosing spondylitis is not curable, most people can lead a fairly decent life unless the disease is severe. Early treatment and regular exercise are the best options to relieve the pain and stiffness of the back and prevent deformity of the spine.

Recent Developments in Science and Technology

□ Biman Basu
Email: bimanbasu@gmail.com

Dead heart brought back to life

Heart attack is a common cause of death. If the attack is mild, prompt medical action can prevent death, but damaged heart muscles can never regenerate. At least that was the belief till recently. Now an American team of researchers have succeeded in 'refurbishing' a dead heart so that it could beat again, a breakthrough that could overcome the shortage of replacement hearts and other organs in future.



Collagen scaffolding of dead heart after removal of muscle cells.

The researchers, led by Doris Taylor at the Centre for Cardiovascular Repair at the University of Minnesota, were able to coax a rat's heart back from the dead by injecting stem cells from newborn rats into the dead heart. Many are hoping this discovery may make it possible in future to re-grow dead organs for transplants. The Minnesota team used a process called 'decellularisation' which involves removing existing muscle cells from the dead heart by using a powerful detergent, while retaining the basic collagen structure intact. Then they injected this gelatine-like scaffold with immature heart cells from newborn rats, fed them a nutrient-rich solution, and left them in the lab to grow. Four days later, the hearts began to contract. The researchers then used a pacemaker to co-ordinate the contractions and hooked up the hearts to a pump circulate nutrients to simulate blood pressure. Eight days later, the hearts started to pump (*Nature Medicine*, 13 January 2008).

Researchers in the past have tried injecting heart stem cells directly into the scarred heart after a heart attack in the hope of regenerating damaged tissue. Taylor and colleagues had also been working on a stem cell therapy to try to heal hearts damaged by heart attacks. But these efforts were unsuccessful. So they looked for other options.

Taylor and colleague Harold Ott knew that decellularisation already had been used in making tissue heart valves and blood vessels and decided to try it on whole organs. They hung the dead hearts in the lab and washed out all the muscle cells with detergents. When the cells were dissolved away only the scaffold, made up of mainly collagen, remained into which the injected cells could grow.

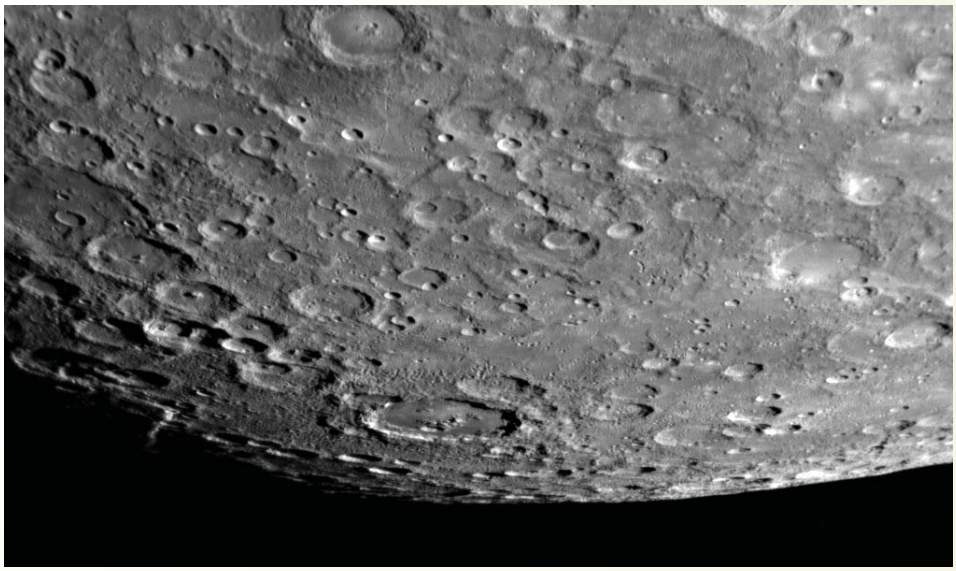
Because a heart created by this new method could also be filled with the recipient's own stem cells, it is thought much less likely to be rejected by the body. And once placed in the recipient, in theory the heart would be nourished, regulated and regenerated similarly to the heart that it replaced. Of course, the regenerated heart is yet to be tested after implanting in a living animal. According to the researchers, the process could be used on other organs too, and possibly offer a potential new source of donor organs such as livers, lungs or kidneys.

MESSENGER reveals unseen face of Mercury

More than three decades after *Mariner-10* flew by Mercury in 1975, another spacecraft *MESSENGER* passed 200 kilometres above Mercury's surface on 14 January 2008 and sent back new images and scientific data. Extensive scientific observations were executed during this flyby encounter, including imaging a large portion of Mercury's surface that had never before been seen by a spacecraft. More than a third of Mercury's surface still remains to be photographed.

MESSENGER (*ME*rcury *S*urface, *S*pace *EN*vironment, *GE*ochemistry, and *R*anging) is the first space mission designed to orbit Mercury, the planet closest to the Sun. It was launched on 3 August 2004 and will now continue on its planned journey, which includes two more flybys of Mercury in October 2008 and September 2009, before entering an orbit around Mercury in March 2011.

During the recent flyby, *MESSENGER* snapped the first pictures



Unseen face of Mercury. This image was acquired about 98 minutes after MESSENGER*'s closest approach to Mercury, when the spacecraft was at a distance of about 33,000 kilometres. (Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington)*

of a side of Mercury not previously seen by a spacecraft. The new image shows a view looking toward Mercury's South Pole. The spacecraft took more than 1,200 images, which are being combined to create multiple mosaics with different resolutions and of different portions of the planet. The creation of high-resolution mosaic images will enable a global view of the planet's surface and will be used to understand the geologic processes that made Mercury the planet we see today.

The gamma-ray and neutron spectrometer and X-ray spectrometer on board *MESSENGER* made the first measurements of Mercury's surface elemental composition. These flyby data will shed light on fundamental scientific questions related to the formation and evolution of the planet. The present encounter will also provide a critical gravity assist needed to keep the spacecraft on track for its 2011 orbit insertion around Mercury.

Making submarines invisible to sonar

When a submarine is fully submerged the only way it can be detected is by using sonar – a device that makes use of sound waves. Sonar detects an object by sending out pulses of sound waves and then detecting the waves reflected back from the target object. If somehow the reflection of sound waves by the target object could be prevented then the object – which may be a submarine – would become invisible to sonar. Although it may sound like science fiction, it is not impossible. Using computer simulations, a team of researchers led by Duke University electrical engineer Steven A. Cummer has determined that it is possible to build objects that will allow sound waves to slip past undisturbed and not produce an echo, a phenomenon called 'acoustic cloaking' (*Physical Review Letters* 18 January 2008). The key to the concept of acoustic cloaking is directing the flow of the sound waves so that waves pass around an object as though it does not exist, and thus no waves bounce back to the listening ears.

Calculations and computer simulations done by Cummer and his team suggest how to achieve a property called 'sonic anisotropy', which allows sound waves to be channelled into one direction no matter from which direction they originate. According to the researchers, the key is synthesising special materials not found in nature that can create anisotropy. Such materials could be, for example, made of precisely fabricated metallic cylinders several centimetres in diameter, or smaller than the wavelength of most audible sounds and therefore able to avoid reflecting them. But getting the ideal material may not be easy. One would need a degree of anisotropy that is more than conventional materials can provide. But it is clear that this kind of sound shaping is technically feasible and researchers have just begun thinking in earnest about where it might be useful in practice.

According to the researchers, the findings might be beneficial in areas such as reducing turbulence by allowing designs for aircraft surfaces and ship's hulls that impede the flow of air or water to a much smaller extent than today's technology can achieve. ■

T. R. Seshadri (Contd. from page...28)

problems…He was without research grants and without means of subsistence…Thus ended the life of a great son of India who was rated by his compeers as one of the most eminent, most dedicated and most fearless among the scientists of the country, and a singular example of simplicity and humility…He never towed the path of worldly success by agreeing with others simply because they were powerful or belonged to influential, scientific or political groups."

Seshadri died on 27 September 1975.

References

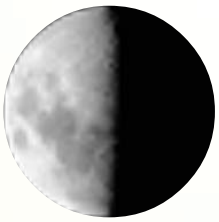
1. N. R. Krishnaswamy. "Professor T R Seshadri—An Acharya par Excellence". *Resonance*, pp. 3-5, February 2004.
2. N. R. Krishnaswamy. "T R Seshadri's Contributions to the Chemistry of Natural Products". *Resonance*, pp. 26-38, February 2004
3. T. R. Seshadri. "Science and National Welfare" in *The Shaping of Indian Science: Indian Science Congress Association Presidential Adresses*, Vol.II:1948-1981, Hyderabad: Universities Press (India) Pvt. Ltd., 2003.
4. S. Rangaswami. "Thirvenkata Rajendra Seshadri" in *Biographical Memoirs of the Indian National Science Academy* (Vol.7), New Delhi, 1983. ■

Sky Map for March 2008

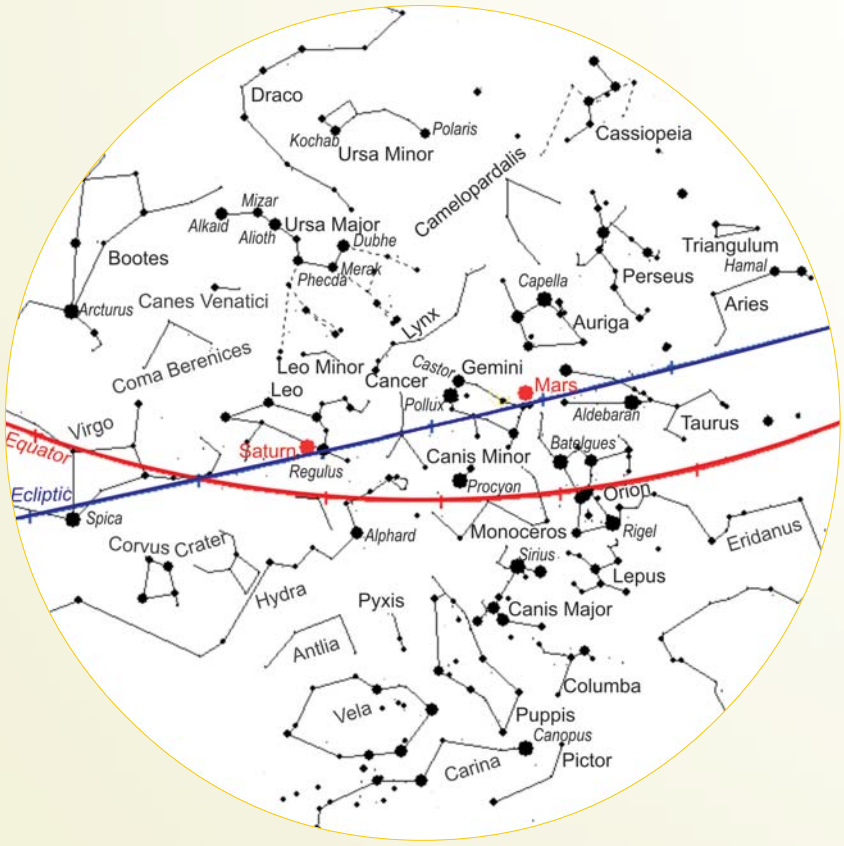
Full Moon

21 March

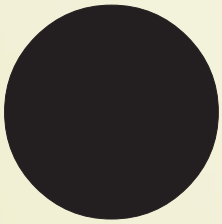
Moon - Last Quarter



29 March

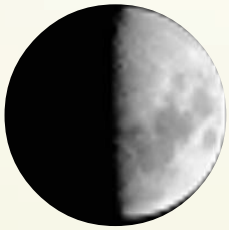


New Moon



7 March

Moon - First Quarter



14 March

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 March, at 9:00 PM on 15 March and at 8 PM on 31 March.

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:

Mars : In the constellation Taurus (*Vrashab Rashi*) up in the zenith sky.

Saturn : In the constellation Leo *(Simha Rashi)* up in the eastern sky.

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

Eastern Sky : Bootes (Arcturus), Canes Venatici, Coma Berenices, Crater, Corvus, Virgo (Spica) / *Kannya Rashi (Chitra)*.

Western Sky : Aries (Hamal) / *Mesha Rashi,* Auriga (Capella), Eridanus, Lepus, Orion (Betelgeuse, Rigel, Saiph), Perseus, Taurus (Aldebaran) / *Vrishabh Rashi,* Triangulum.

Southern Sky : Antlia, Canis Major (Sirius), Carina (Canopus), Columba, Hydra (Alphard), Pictor, Puppis, Pyxis, Vela.

Northern Sky : Camelopardalis, Cassiopeia / *Sharmishtha*, Draco, Ursa Major/ *Saptarishi*, Ursa Minor (Polaris) / *Dhurva Matsya* (*Dhurva Tara*).

Zenith : Cancer / *Karka Rashi*, Canis Minor (Procyon), Gemini (Castor, Pollux)/*Meethun Rashi*, Leo (Regulus) / *Simha Rashi (Magha),* Leo Minor.

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

Earthquake Tip-21

Why are Open-Ground Storey Building Vulnerable in Earthquakes?

Basic Features

Reinforced concrete (RC) frame buildings are becoming increasingly common in urban India. Many such buildings constructed in recent times have a special feature – the ground storey is left open for the purpose of parking (Figure 1), i.e., columns in the ground storey do not have any partition walls (of either masonry or RC) between them. Such buildings are often called 'open ground storey buildings or buildings on stilts'.

Figure 1: Ground storeys of reinforced concrete buildings are left open to facilitate parking – *this is common in urban areas in India.*

An open ground storey building, having only columns in the ground storey and both partition walls and columns in the upper storeys, have two distinct characteristics, namely:

(a) It is relatively flexible in the ground storey, i.e., the relative horizontal displacement it undergoes in the ground storey is much larger than what each of the storeys above it does. This flexible ground storey is also called soft storey.

(b) It is relatively weak in ground storey, i.e., the total horizontal earthquake force it can carry in the ground storey is significantly smaller than what each of the storeys above it can carry. Thus, the open ground storey may also be a weak storey.

Often, open ground storey buildings are called soft storey buildings, even though their ground storey may be soft and weak. Generally, the soft or weak storey usually exists at the ground storey level, but it could be at any other storey level too.

Earthquake Behaviour

Open ground storey buildings have consistently shown poor performance during past earthquakes across the world (for example during 1999 Turkey, 1999 Taiwan and 2003 Algeria earthquakes); a significant number of them have collapsed. A large number of buildings with open ground storey have been built in India in recent years. For instance, the city of Ahmedabad alone has about 25,000 five-storey buildings and about 1,500 eleven-storey buildings; majority of them have open ground storeys. Further, a huge number of similarly designed and constructed buildings exist in the various towns and cities situated in moderate to severe seismic zones (namely III, IV and V) of the country. The collapse of more than a hundred RC frame buildings with open ground storeys at Ahmedabad (~225km away from epicenter) during the 2001 Bhuj earthquake has emphasised that such buildings are extremely vulnerable under earthquake shaking.

The presence of walls in upper storeys makes them much stiffer than the open ground storey. Thus, the upper storeys move almost together as a single block, and most of the horizontal displacement of the building occurs in the soft ground storey itself. In common language, this type of buildings can be explained as a building on chopsticks. Thus, such buildings swing back-and-forth like inverted pendulums during earthquake shaking (Figure 2a), and the columns in the open ground storey are severely stressed (Figure 2b). If the columns are weak (do not have the required strength to resist these high stresses) or if they do not have adequate ductility (See *IIT-BMTPC Earthquake Tip*

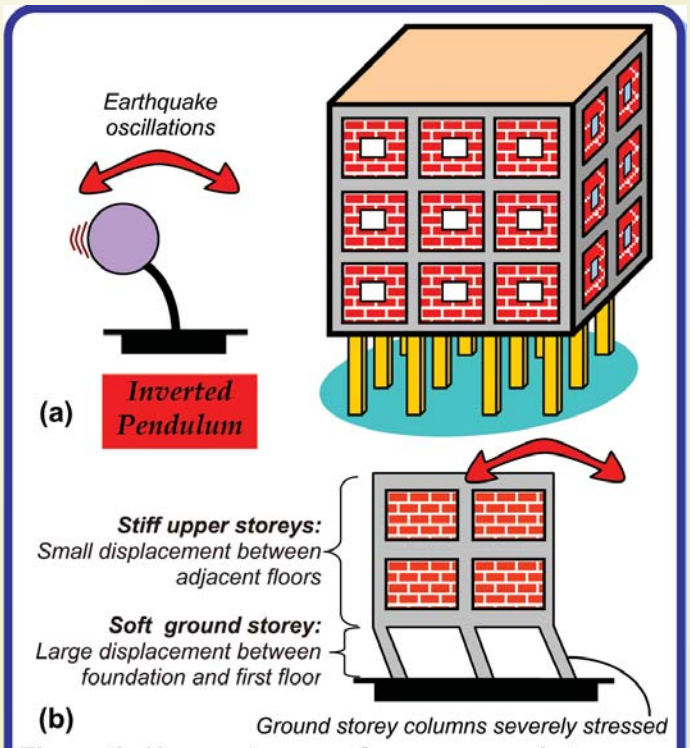
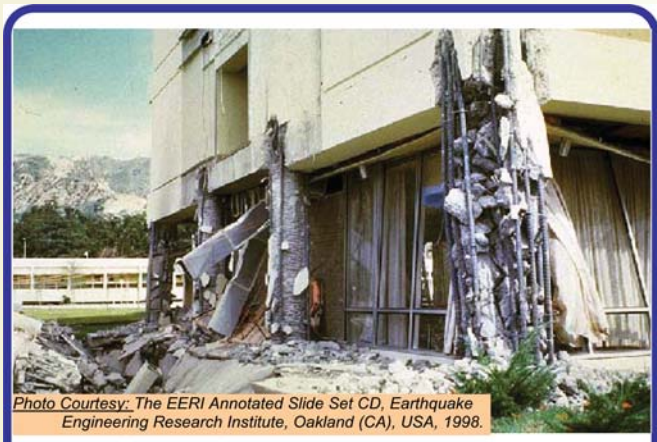


Figure 2: Upper storeys of open ground storey buildings move together as a single block – *such buildings are like inverted pendulums.*

9), they may be severely damaged (Figure 3a) which may even lead to collapse of the building (Figure 3b).



(a) 1971 San Fernando earthquake

(b) 2001 Bhuj earthquake

Figure 3: Consequences of open ground storeys in RC frame buildings – *severe damage to ground storey columns and building collapses.*

The Problem

Open ground storey buildings are inherently poor systems with sudden drop in stiffness and strength in the ground storey. In the current practice, stiff masonry walls (Figure 4a) are neglected and only bare frames are considered in design calculations (Figure 4b). Thus, the inverted pendulum effect is not captured in design.

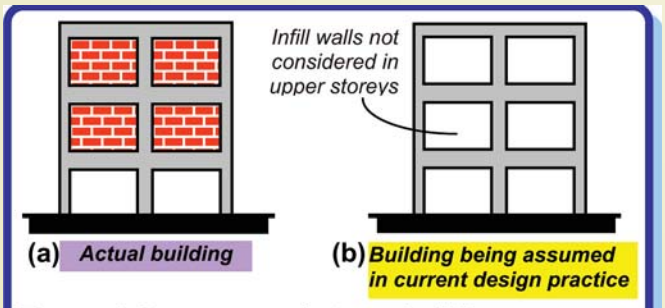


Figure 4: Open ground storey building – *assumptions made in current design practice are not consistent with the actual structure.*

Improved design strategies

After the collapses of RC buildings in 2001 Bhuj earthquake, the Indian Seismic Code IS:1893 (Part 1) -2002 has included special design provisions related to soft storey buildings. Firstly, it specifies when a building should be considered as a soft and a weak storey building. Secondly, it specifies higher design forces for the soft storey as compared to the rest of the structure. The code suggests that the forces in the columns, beams and shear walls (if any) under the action of seismic loads specified in the code, may be obtained by considering the bare frame building (without any infills) (Figure 4b). However, beams and columns in the open ground storey are required to be designed for 2.5 times the forces obtained from this bare frame analysis.

For all new RC frame buildings, the best option is to avoid such sudden and large decrease in stiffness and/or strength in any storey; it would be ideal to build walls (either masonry or RC walls) in the ground storey also (Figure 5). Designers can avoid dangerous effects of flexible and weak ground storeys by ensuring that too many walls are not discontinued in the ground storey, *i.e.,* the drop in stiffness and strength in the ground storey level is not abrupt due to the absence of infill walls.

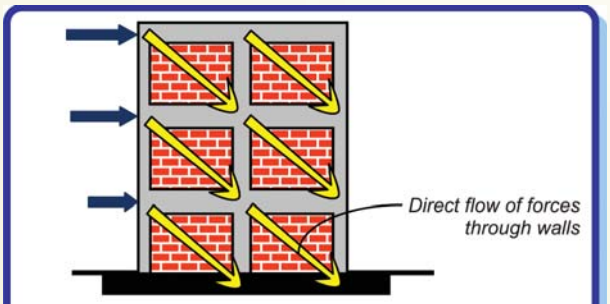


Figure 5: Avoiding open ground storey problem – *continuity of walls in ground storey is preferred.*

The existing open ground storey buildings need to be strengthened suitably so as to prevent them from collapsing during strong earthquake shaking. The owners should seek the services of qualified structural engineers who are able to suggest appropriate solutions to increase seismic safety of these buildings.

Related IITK-bMTPC Earthquake Tip

Tip 6 : How Architectural Features Affect Buildings During Earthquakes?

Tip17 : What are the Earthquake Effects on Reinforced Concrete Buildings?

Resource Material

1. IS 1893(Part 1) (2002), *Indian Standard Code of Practice for Criteria for Design of Earthquake Resistant Structures*, Bureau of Indian Standards, New Delhi.

Acknowledgement :
Authored by : C.V.R.Murty, Indian Institute of Technology Kanpur, Kanpur, India.
Sponsored by : Building Materials and Technology, Promotion Council, New Delhi, India

Editorial (Contd. from page 31)

January 2008, *MESSENGER* also made the first measurement of Mercury's magnetospheric plasma. During the next two flybys of *MESSENGER* in 2008 and 2009, and when it eventually enters elliptical orbit around Mercury in 2011 to study the planet for a year, we may learn more about the stability and dynamics of Mercury's magnetic field. *MESSENGER* would come as close as 200 kilometres from Mercury's surface during its orbit. During the recent flyby, *MESSENGER*'s instruments detected ultraviolet emissions from sodium, calcium and hydrogen in Mercury's super-low-density atmosphere – called exosphere. It was probably formed from atoms sputtering off Mercury's surface and coming in contact with hot plasma trapped in Mercury's magnetic field. *MESSENGER* also encountered Mercury's sodium-rich exospheric "tail", which extends more than 40,000 kilometres from the planet, and discovered a hydrogen tail of similar dimensions.

Given the fact that there are inherent difficulties in ground observation of the planet Mercury, how is it that there have been so few space missions to Mercury till date as compared to other planets? This is mainly because reaching Mercury from the Earth poses significant technical challenges since it orbits the Sun so much closer than does the Earth. So, when a spacecraft arrives close to Mercury, it is greeted by a hostile environment and must, therefore, be designed to withstand high radiation and temperatures. The energy required to send a spacecraft so close to the Sun is significant, and an orbital mission only increases this requirement. Incidentally, *MESSENGER* is the first spacecraft for which the technologies needed for a Mercury orbital mission were available and combined in an effective manner.

What would *MESSENGER* look for, on planet Mercury, anyway? The mission is designed to shed light on six key issues: Mercury's high density, its geological history, the nature of its magnetic field, the structure of its core, whether it really has ice at its poles, and where its tenuous atmosphere comes from. The probe is carrying imaging devices which will gather much higher resolution images of much more of the planet than *Mariner-10*, and assorted spectrometers to determine abundances of elements in the crust. It is also carrying magnetometers and devices to measure velocities of charged particles. Detailed measurements of tiny changes in the probe's velocity as it orbits would give details of the planet's interior structure.

Mercury's high density implies that a metal-rich core occupies at least 60% of the planet's mass, a figure twice as great as for Earth! *MESSENGER* will acquire compositional and mineralogical information and help understand why it is so dense. Only 45% of the surface of Mercury was imaged by *Mariner-10*! *MESSENGER* mapped another 30 per cent during its recent flyby, and will map the remaining surface during the course of its mission. Mercury has a global internal magnetic field, as does Earth, but Mars and Venus do not. By characterizing Mercury's magnetic field, *MESSENGER* will help answer the question of why the inner planets differ in their magnetic histories.

Through a combination of measurements of Mercury's gravity field and observations by the laser altimeter, *MESSENGER* will determine the size of Mercury's core. At Mercury's poles, some crater interiors have permanently shadowed areas that contain highly reflective material at radar wavelengths. Could this material be ice, even though Mercury is the closest planet to the Sun? *MESSENGER* will find out.

Orbiting so close to the Sun, Mercury feels its gravitational pull most keenly, making it the perfect place to test general relativity. *MESSENGER* is not designed to test fundamental physics. However, fortunately it is not the only mission we can look forward to. The European and Japanese space agencies plan to launch a joint mission to Mercury in 2013, and this one does plan to test fundamental physics. Called BepiColombo, it is larger than *MESSENGER* and will consist of two orbiting spacecraft. One will scrutinize the surface of the Mercury while the other will investigate the details of the magnetic field. It is named after Giuseppe (Bepi) Colombo, the scientist who first determined that Mercury rotates three times for every two revolutions around the Sun, and is not synchronously locked with the Sun keeping the same face towards it, as it was earlier thought. He was also involved in the planning of the *Mariner-10* trajectory to the planet in 1974.

With two flybys yet to come and an intensive year-long orbital mission yet to follow, we are in for more surprises and data that may help us understand the processes that also produced Earth, Venus and Mars – the other terrestrial planets having a rocky body.

Vinay B. Kamble

Letters to the Editor

Promoting scientific outlook

The contribution by the late Rakesh Popli (January 2008) should be an eye opener to those who pursue science with an orthodox approach. The motto "Seeing is believing" is utterly restrictive and at times deceptive too. The articles in *DREAM 2047* can truly help in promoting the scientific outlook and inculcating true scientific temper.

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Workshop on Innovative Experiments in Physics

A state level workshop on innovative experiments in physics was organised by Vigyan Prasar in association with Gujarat Science City, during 11-13 January 2008 at Ahmedabad. 70 participants comprising higher secondary schools and college physics teachers selected from different districts of Gujarat attended the workshop.

(From Left to Right): Shri B. K. Tyagi, Scientist, Dr. A. P. Mehta, Dr. V. B. Kamble, Shri Ashok Mehta, during the inauguration of the workshop

Shri Ashok Mehta, Executive Director, Gujarat Science City welcomed the participants and dignitaries. Prof. A. P. Mehta, Vice President, Indian Association of Physics Teachers (IAPT), Western Region, briefed the teacher participants about the activities of IAPT for physics education and requested the participants to take an active role in popularisation of physics at school and college level.

Dr. V. B. Kamble, Director, Vigyan Prasar formally inaugurated the workshop on 11 January 2008. In his inaugural address, Dr. Kamble observed that science is based on observations and experimentally found facts. He urged the participants to utilise the workshop to design experiments which can be done without any formal laboratory set-up and implement these innovative ideas in their respective institutes. Dr. Kamble also gave an insight to the various activities and programmes undertaken by Vigyan Prasar to popularise science among different target groups in society.

Prof. H. C. Verma of the Department of Physics, IIT Kanpur – a pioneer in designing novel activities in physics aimed at enhancing interest in physics amongst students and teachers conducted the workshop and gave demonstrations of a number of innovative experiments in different topics of physics through interactive sessions and participatory approach. He said there are two types of experiments that may be employed in the teaching of physics. One type includes science-oriented or quantitative experiments, designed primarily to allow the study of phenomena under reproducible conditions, e.g., measuring the acceleration g of freely falling bodies in the gravitational field of the Earth using a metal sphere and light barriers. Quite often these experiments are intended to give students an opportunity to quantitatively test a theoretical hypothesis. The necessity of this type of experiments for the advancement of physics is obvious, for they are an essential in the grooming of future scientists.

The second type includes experiments that are motivational in nature and designed primarily to provide students with a qualitative encounter with physical or technical phenomena or processes. Low-cost and hands-on experiments belong to this latter category. Whereas the former type of experiments often only attract a limited number of students, the latter offers the possibility of reaching more students and raising interest in the natural sciences in general. Dr. Brijesh Pandey, Research Associates at IIT, Kanpur, and Mrs. Smita Fangaria, physics teacher at Amity International School, Noida, assisted Dr. Verma in experimental sessions.

Professor H. C. Verma, IIT Kanpur (second from right), and Dr. Brijesh Pandey, Research Associate, IIT Kanpur (Right) demonstrating innovative experiments in physics.

Prof. Verma delivered a popular science lecture on "Indian Science: Past, Present and the Future" highlighting India's rich S&T heritage and also gave an account of the present situation in science education and research. He advised the participants to motivate younger students in science and to help in developing a qualitative scientific pool for the country.

Shri B. K. Tyagi, Scientist, Vigyan Prasar gave a presentation on Vigyan Prasar activities and programmes for the year 2008, which has been declared the International Year of Planet Earth. A 26-episode television serial in Hindi, a 52-episode radio serial in 19 Indian languages being aired from 117 stations of AIR, and a number of books, kits, posters, and slide shows are planned by Vigyan Prasar.

Shri Rintu Nath, Scientist, Vigyan Prasar demonstrated a few experiments that can be performed using a PC. Vigyan Prasar has developed a PC interface for science experiments using which parameters like temperature, light, sound intensity, humidity, voltage, current, etc., can be measured. The parameters can also be controlled through closed loop feedback control mechanism. This kit offers user interface that enables any user to customise and scale a new type of sensor for specific application. The innovative idea and the demonstration generated a lot of enthusiasm among the participants.

Shri Rintu Nath (Right), Scientist, Vigyan Prasar demonstrating PC based science experiments to the participants

Dr. R. P. Dubey, Senior Scientist at Space Applications Centre (ISRO), Ahmedabad delivered a popular science lecture on Excitement in Space Science Research and Technology. Dr. Dubey gave a presentation on the various research and development of projects undertaken by ISRO and also discussed *Chandrayaan-I*, the country's indigenous Moon Mission.

The programme concluded with a formal valedictory programme attended by Dr. A. M. Prabhaker, Advisor & Head, Gujarat Council on Science & Technology (GUJCOST), Dr. V. B. Kamble, Director, Vigyan Prasar, Dr. Madhuben Shah, IAPT, Gujarat, Shri Ashok Mehta, Gujarat Science City, and Dr. Narottam Sahoo, Senior Scientist, Gujarat Science City.

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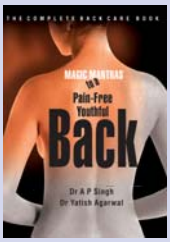

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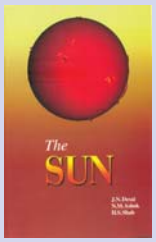

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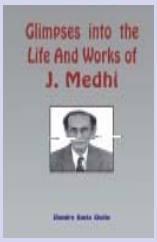

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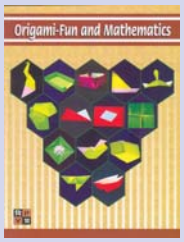

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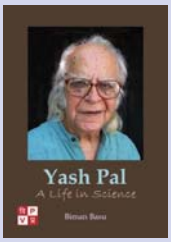

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