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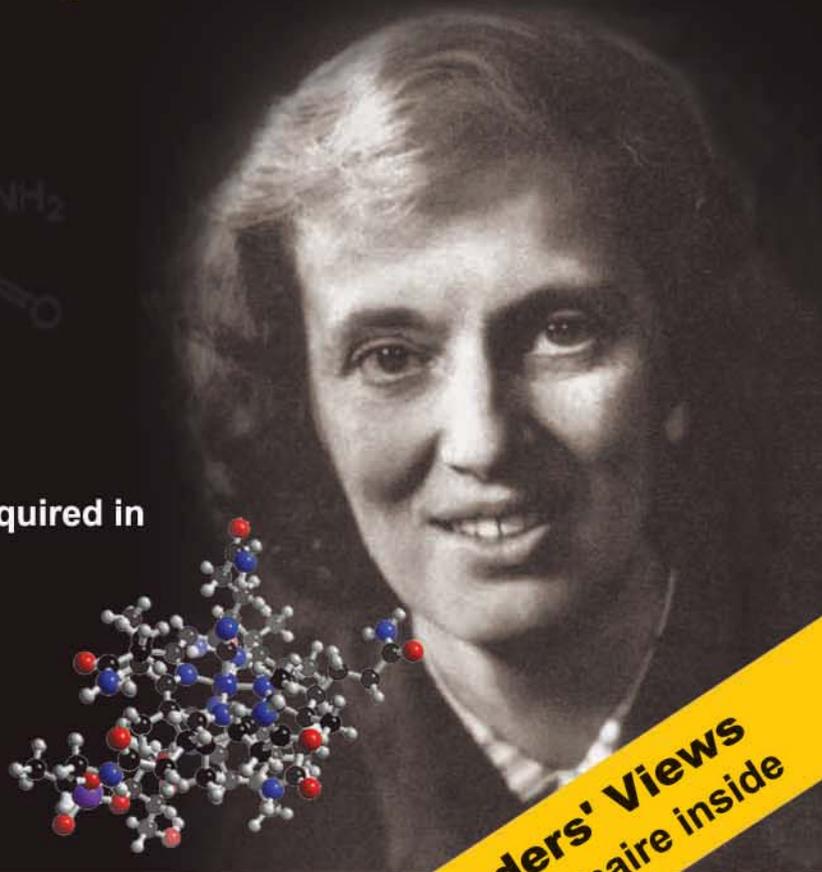
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Dorothy Hodgkin

Founder of protein crystallography



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Rivers at Risk

Most of the ancient civilizations grew along the banks of the rivers. Even today, 41 per cent of the world's population lives in river basins and depends on rivers for survival. A river may have a source in a glacier, a spring, or a lake; and begin as a small stream and grow wider as smaller streams and rivers join it. Eventually, it flows into a sea or an ocean. It does not have any doubt about where it is going; and it does not want to go anywhere else! There was a time when that was true, but not any longer! A river's strength is sapped by dams and irrigation works diverting water to farmlands and city water supplies. The Rio Grande River on the border of USA and Mexico often fails to reach the Gulf of Mexico. The once mighty rivers like the Indus, the Nile in Egypt, and the Colorado in USA also have to struggle to touch the ocean.

Freshwater ecosystems are rivers, streams, springs, lakes, ponds, groundwater, floodplains and wetlands. Rivers are surface waters flowing down from higher altitude to lower altitude, and it is in the river basins that nature gathers and delivers water for human use. Rivers provide habitat for diverse flora and fauna, sediment and nutrient retention, transport, electricity generation, recreation and tourism. In India and other developing countries, such freshwater ecosystems and biodiversity provide food, income and livelihood to rural communities. However, freshwater environments tend to have the highest proportion of species threatened with extinction; and today

the threats to freshwater ecosystems are immense. Incidentally, more than 20 per cent of the world's 10,000 fresh water species have already become extinct, threatened or endangered.

What are the challenges faced by a river during the course of its journey? Water extraction is a major challenge, but not the only challenge. Dams and canals destroy habitats that are home to several plant and animal species. Physical alteration, habitat loss and degradation, over-fishing, pollution and introduction of invasive species threaten the freshwater ecosystems and their biological resources. Incidentally, an invasive species is a plant or an animal that is intentionally or unintentionally introduced to a region in which it did not naturally evolve, and in its new environment, it may grow to overwhelm native species and communities. Further, freshwater ecosystems naturally filter and purify water, but this ability is impaired by excessive pollution and habitat degradation. Hence, pollution can turn life-giving waters into a hazard to health. Finally, global warming and climate change could completely change the very character of the river we have known for thousands of years.

It may now become impossible to preserve rivers as life-giving watercourses unless we address the factors that threaten their health with a sense of urgency. This is the stark message contained in the assessment of the world's 10 magnificent rivers in different continents released by World Wide Fund for Nature (WWF) some

time ago. According to WWF assessment, in the last fifty years we have altered the ecosystems more rapidly and extensively than in any other period of history, the major causes being the rapid population growth, economic development and industrialization that have led to the unprecedented transformation of the freshwater ecosystems and the consequent biodiversity loss.

According to WWF Report, the Salween (Asia), the Danube (Europe) and the La Plata (South America) face heavy threats from navigation and damming. The Rio Grande (USA) and the Ganges face problems from over-extraction of water for increasing irrigation and domestic consumption. The Indus and the Nile (Africa) face the threat from climate change. The Indus depends heavily on glacier water, while the Nile basin is very sensitive to increase in temperature because of its high rate of evaporation. The Murray-Darling in Australia is a victim of invasive species. The Mekong (Asia) faces the problem of over-fishing. Finally, the Yangtze (China) is a victim of high pollution. WWF has relied upon eight international studies to make this assessment. However, we must note that most of the rivers suffer from the various factors described here to a lesser or a greater extent.

The warnings of WWF should serve as a reminder that time may be running out for our rivers, let alone the Ganges. The Ganges is a biodiversity-

(Contd. on page 27)

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Dorothy Crowfoot Hodgkin

Founder of protein crystallography

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“The word ‘scientist’ evokes different images in people. There is a conventional caricature of a scientist as an absent-minded, dry recluse pursuing a chosen problem with single-minded devotion. Then there is a current image of a scientist-manager raising large funds, filling patents, hopping from meeting to meeting, leading large teams and producing results of great import to science as well as industry. These or other images do not fit Dorothy Crowfoot Hodgkin. Undoubtedly, she was an outstanding scientist with great achievements to her credit. She was a great humanist deeply concerned with peace, justice and human well-being, a devoted wife, mother and grandmother, a person full of life, warmth and compassion.”

M. Vijayan in Resonance, June 1998

“Dorothy Hodgkin developed the X-ray diffraction method of finding the exact structure of a molecule (originally developed by the Braggs) and applied it to complex organic molecules. Among her most striking successes were the antibiotic penicillin, whose structure she deduced in 1956 (before it had been deduced by purely chemical methods), and vitamin B12, lack of which leads to pernicious anaemia. This vitamin has over 90 atoms in a complex structure, and her analysis in 1956 (after 8 years of work) was a high point for X-ray methods.”

The Cambridge Dictionary of Scientists (2002)

Dorothy Crowfoot Hodgkin is regarded as one of the foremost scientists in the field of protein crystallography. She was one of the founders of the field of protein crystallography. She was awarded the 1964 Nobel Prize in Chemistry “for her determinations by X-ray techniques of the structures of important biochemical substances.” As we know, the properties of a molecule are very much dependent on their structure. For structural analysis Hodgkin extended the application of X-ray crystallography, which was first used by William and Lawrence Bragg to determine the simple cubic structure of sodium chloride crystals. Hodgkin and her colleagues took the first X-ray diffraction photograph of the protein pepsin at Cambridge in 1934. They also determined the structures of insulin and a number of steroids including cholesterol, and took the first X-ray photograph of vitamin B₁₂, one of the most complex non-protein compounds. This vitamin has more than 90 atoms in a complex structure. They completely determined the atomic arrangement of vitamin B₁₂. It was a high point for X-ray methods.

Commenting on her approach to research, one of her colleagues wrote: “She was very intuitive in her science. She had clear objectives when she chose to study



Dorothy Crowfoot Hodgkin

the crystals; she believed that their biological function would be revealed through their crystal structure. Each was a challenge crystallographically; she thought it could be done, and she was willing to persevere for years.”

The most important thing about Dorothy Hodgkin is that besides being a great scientist, she was also great as a human being. She loved to share her ideas with others. She was a great support to her students and colleagues. She was passionate about inequalities and peace. She played an important role in promoting international understanding. M. Vijayan, who worked with her, wrote: “Dorothy was a great scientist. But she was much else. There are not many who have done as much as Dorothy did in her own unobtrusive yet effective way, to promote international understanding. She was deeply rooted in British, particularly Oxford, traditions. Yet she was a great internationalist. Of the hundred and odd scientists who worked in Dorothy’s laboratory, only about 25 were British. She took care to see that her research group was cosmopolitan. Her colleagues included seven Indians (K. Venketeshan, B. Basak, S. Ramaseshan, M. A. Viswamitra, Kalyani Vijayan, M. N. Sabesan and myself). She visited India several times and, as in other parts of the world, has had tremendous influence on its scientific community.”

Dorothy Hodgkin was born on 12 May 1910 in Cairo, Egypt. At the time



J. D. Bernal

of her birth, her father John Winter Crowfoot was serving in the Egyptian Education Service. In those days Egypt was under the British protection. Dorothy's father moved to Khartoum, Sudan to serve there in the education department and eventually rose to become Directors of Education and of Antiquities. Her mother, Grace Mary Crowfoot (*nee* Hood) used to assist her husband in his work. She was considered an authority on early weaving techniques. She was very much interested in botany and she made illustrations for an official publication titled *Flora of the Sudan*. Dorothy was fond of Sudan, which she first visited as a girl in 1923.

At an early age Dorothy became interested both in chemistry (particularly in crystals and identifying minerals) and archaeology. Her parents encouraged her to study science. One Dr. A. F. Joseph, a family friend in Sudan, presented her a chemistry kit. This was supposed to have sparked off her interest in chemistry. During her stay at Sudan, Dr. Joseph helped her analyse limonite, an important ore of iron. She set up a small laboratory of her own in the attic of her home and she used to spend hours in her laboratory doing experiments. It is said that her visit

to the Wellcome Laboratories at Khartoum in her childhood played an important role in developing her interest in science. She was also influenced by the Christmas lectures of Sir William Henry Bragg (1862-1942) and Parson's book on biochemistry.

She spent most of her childhood at Geldeston in Norfolk, a county in Eastern England. However, she frequently visited Cairo and Khartoum. In 1921, she attended the Sir John Lemn School at Beccles, Suffolk and she studied there till 1928.

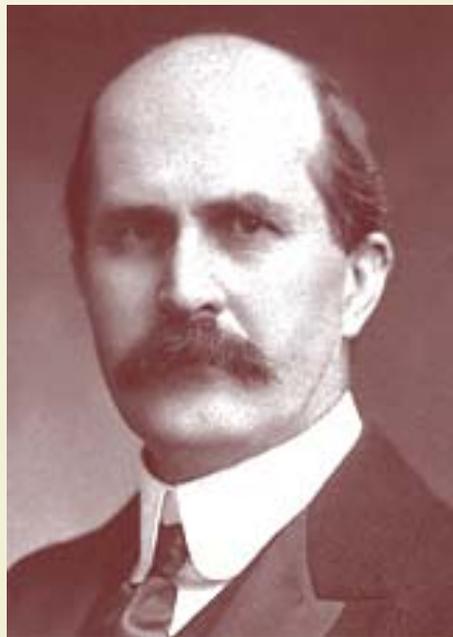
In October 1928, she joined the Somerville College of the Oxford University. In those days this college was for women only. In the first year of her college for a brief period she combined archaeology and chemistry. However, persuaded by her tutor F. M. Brewer she gave up archaeology and continued to study chemistry with special emphasis on X-ray crystallography. Her chemistry course was for four years and it included one year of compulsory research. She worked with H. M. Powell on thallium dialkyl halides. She also made a brief summer visit to Victor Goldschmidt's laboratory in Heidelberg. In 1933, she graduated from Somerville and was given a two-year research fellowship by the college, to work one year at Cambridge and the second year at Oxford.

She went to Cambridge to work with John Desmond Bernal (1901-1971). She worked with Bernal for two years. Bernal was keen to use the technique of X-ray diffraction analysis for studying important complex organic molecules. To realize his objective Bernal gathered around him a team of enthusiastic and intelligent scientists to work out the appropriate techniques. Hodgkin became a member of this team and probably she was the most talented of all the members. It was at Bernal's laboratory at Cambridge where she realized the potential of X-ray crystallography to determine the structure of proteins. She was greatly influenced by Bernal's ideas both scientifically and politically.

In 1934, she came back to Oxford and remained there till the end of her

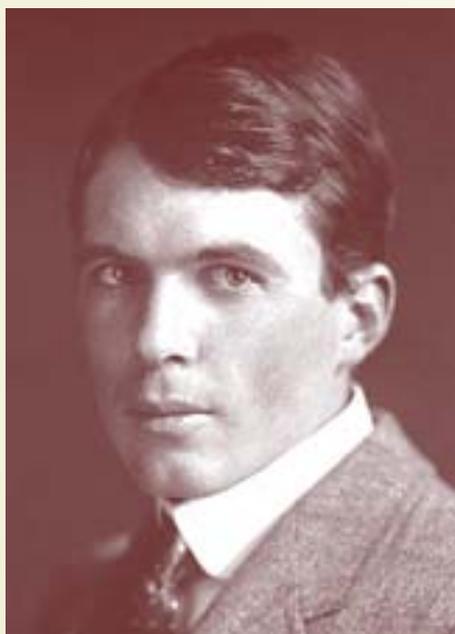
career. For the most part of her career, Hodgkin worked as Official Fellow and Tutor in Natural Science at Somerville. Her main responsibility was to teach chemistry in women's colleges. In 1946, she was appointed as a University lecturer and demonstrator. In 1956 she became a University Reader in X-ray crystallography. In 1937, Hodgkin was awarded PhD degree by the Cambridge University. In 1960, she was appointed Wolfson Research Professor of the Royal Society.

On coming back to Oxford in 1934, Hodgkin met Ernst Boris Chain (1906-1979), who later received the 1945 Nobel Prize for Medicine or Physiology jointly with Alexander Fleming (1881-1955) and Howard Walter Florey (1898-1968) for their work on penicillin. This meeting stimulated her interest in determining the structure of penicillin. She started working



William Henry Bragg

on the structure of penicillin in 1942. Commenting on the structural determination of penicillin Hodgkin said: "The initiation of the research on penicillin had nothing to do with the war, which indeed was a hindrance in the early stages to its prosecution. It was difficulties in persuading British firms in wartime to undertake the large scale extraction of penicillin that led Florey to go to America in 1941 to interest American firms and



William Lawrence Bragg

government research laboratories in its preparation...some of the first crystalline penicillin obtained in America was flown over to me in Oxford (10 mg) and used in structure analysis. But the analysis by X-ray diffraction was actually carried out in the usual academic way by one D Phil student Barbara Low (aged 21), some part time help from Charles Bunn and his research assistant, Ann Turner-Jones, then in industrial research at ICI (at first they worked after their official working hours), and myself, partly distracted by university teaching, by child bearing, evacuation problems in the war, even occasional bombing episodes. The delight we had in the atomic arrangement of the atoms in penicillin which we saw in 1945 was hidden from the scientific public by the war organization."

Hodgkin started working on the structure vitamin B₁₂ in 1948, when Lester Smith of the Glaxo drug company made her available the crystal samples of the vitamin. Hodgkin and her group worked out the structure of the vitamin in 1956. This happened to be the largest molecule to be taken up for structural determination.

Hodgkin herself considered the deciphering the structure of insulin as her greatest scientific achievement. She took 35 years to complete the deciphering of the three-dimensional

structure of insulin, the smallest protein containing only 51 amino acids. Larger proteins have hundreds of amino acids. The total number of atoms present in insulin is 777. Frederick Sanger had worked out the sequence of amino acids in insulin. Hodgkin demonstrated that insulin is a six-part molecule and is roughly triangular in shape. Hodgkin started working on insulin in 1934, when she was given a small sample of crystalline insulin by Robert Robinson (1886-1975). She was particularly interested in working on insulin because of its wide-ranging effect on human body. In 1934, X-ray crystallography was not developed to an extent that it could tackle the complexity of a molecule like insulin. So Hodgkin and others spent years in improving the technique. The structure was finally deciphered in 1969. The development of advanced computing played an important role.

Hodgkin was greatly concerned with social uplift. She was outspoken. In her lecture given in memory of Maulana Abul Kalam Azad, India's first education minister, in New Delhi in 1973 she said: "But, you may say, all these discoveries I have described have led to happiness for certain individuals only, who might have died, but who lived. For others, these discoveries may have made life even



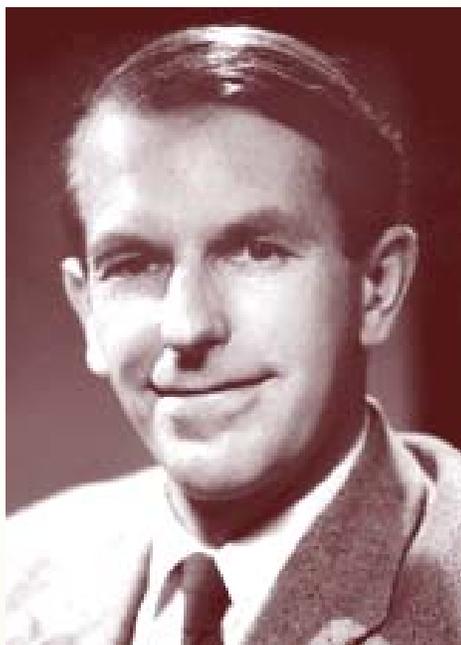
Ernst Boris Chain



Robert Robinson

more difficult and particularly in India, more people living than ever before and food still often scarce. I find myself thinking that you can only solve problems if you really work on them, intensively, with everyone working together. Gandhi once said 'Anything that millions can do together becomes charged with a unique power.' There has already been experience in different parts of the world in the techniques by which poverty can be diminished; it is necessary first to raise the standard of living for the poorest; and this requires the cooperation of everyone, work from all for everyone's needs. In my own wanderings I have seen this transformation of life happening in different degrees in many countries and particularly most recently in China and Vietnam." Her statement is indeed very much true even today. We need to raise the standard of living for millions of our people.

Hodgkin was elected a Fellow of the Royal Society of London in 1947. Among her many awards were: Copley Medal of the Royal Society of London (1976); and Lomonosov Gold Medal (1978) and Lenin Peace Prize (1987) of the erstwhile USSR. The Order of Merit, the United Kingdom's highest Royal Order, was conferred upon her



Frederick Sanger

in 1965 by Queen Elizabeth II; she was only the second woman after the legendary Florence Nightingale to receive this award. She was Chancellor of Bristol University from 1970 to 1988; President of the International Union of Crystallography (1972-1978);

and President of the British Association for the Advancement of Science (1977-78). She appreciated the importance of the efforts in popularising science. She was the President of the Pugwash Conference.

The Indian Academy of Sciences, Bangalore has published *The Collected Works of Dorothy Crowfoot Hodgkin* (3 volumes). The volumes have been edited by G. G. Dodson, J. P. Glusker, S. Ramaseshan and K. Venkatesan. Her biography, *Dorothy Hodgkin: A Life* by Georgina Ferry was published in 1998 by Granta Books, London.

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

Editorial (Contd. from page 31)

rich and culturally important river system. An estimated 60 per cent of flows of its tributaries are used for agriculture. WWF projection indicates that the annual renewable flow of the Ganges could slip into a situation of scarcity by 2025 despite the fact that per capita supply at present is generally adequate. Further, climate change has been affecting the Himalayan glaciers which provide an estimated 30 to 40 per cent of present flows. Environmentally disruptive projects, that is, dams are used to store vast quantities of water for farming, drinking, and power generation. At this juncture, one may note that according to a recent study, hydroelectric plants release millions of tonnes of polluting greenhouse gases - carbon dioxide and methane - into the atmosphere every year as bacteria degrade the vegetation submerged in

their giant reservoirs! Hence, hydroelectric power may not be as green as we may think! Next, surface water extraction is increasing in States that lie along the river's course; and more diversion of waters is planned. There is no gainsaying the fact that grave environmental threats such as pollution, building of unsustainable dams, excessive extraction of water, climate change, and over-fishing are taking their toll on the health of our rivers. By and large, what holds true for the Ganges also holds true for other rivers of our country.

What are the immediate measures we need to take? First and foremost, we must make more economical use of water for agriculture and other purposes. Action plans to clean up rivers like the Ganges and the Yamuna must involve community participation. We shall also need to devise an effective system

to conclude enforceable water agreements among States that share the same river basin. Rivers and their rich diversity of plants and animals can be better protected if community-based rainwater harvesting practices are strengthened. Since burning of fossil fuels contributes to global warming and thereby accelerating the melting of the Himalayan glaciers, it is imperative to reduce the use of fossil fuels and develop renewable sources of energy. This holds true both for developed as well as the developing nations. Massive investments in sanitation, sewage treatment, and pollution control are equally important to keep the rivers healthy. But, the real challenge would be to transform this effort into a people's movement. Our rivers will then continue to flow nurturing the communities for ever.

□ Vinay B. Kamble

The Origin of the Universe*

□ By K.D. Abhyankar

The problem of the origin of the Universe has been with us from the earliest periods of the human civilization. Peoples of various countries have answered the question at different epochs depending upon their limited experiences and according to their general philosophical attitude. There are accounts of the creation of the Universe in early Babylonian and Chinese texts, in the Hindu Puranas, in the Bible, and in the American Indian and African folklore. It is interesting to note three distinct pictures, albeit speculative, presented by the early civilizations which have their counterparts in the modern cosmological theories. The Christian and Islamic theologies conceive of a beginning and an end of the Universe. The Chinese, on the other hand, would believe that the Universe is everlasting, while the Indians would prefer a cyclically changing Universe with repeated creation and destruction. These three attitudes correspond respectively to the “big bang” theory of the modern cosmology, of which George Gamow was one of the ablest exponents; “the steady state” theory propounded by Thomas Gold, Hermann Bondi, and Fred Hoyle of the Cambridge school; and the theory of the pulsating Universe. It should be our aim to test their validity on the basis of modern scientific observations made with the best and the most up-to-date instruments available to us.

The early scientific attempts starting from the French mathematician Pierre-Simon Laplace in 1796 were concerned with the theory of the origin of the solar system. It is now realised that ours is not a unique planetary system. According to American astrophysicist S.S. Huang and others,

one out of every one hundred thousand stars may be associated with Earth-like planets inhabited by intelligent beings; planets without life would of course be much more frequent. In fact there is no distinction between planetary systems and binary stars except in the magnitude and distribution of angular momentum. Since almost half of all the stars are members of binary or multiple systems, the problem of the origin of the solar system is connected with the bigger problem of the formation of stars in general. Now, there are reasons to believe that the stars are formed in groups of 1,000 to 100,000 under certain conditions, which at present occur only in the spiral arms of our Galaxy. In order to explain the occurrence of 100 billion stars in the Milky Way we have to postulate that the conditions ought to have been different in the remote past. In other words the galaxies including our own have been undergoing a continuous evolution. The question then arises: Is the Universe of galaxies itself evolving? Or, is the Universe as a whole unchanging in spite of the evolution of its constituents? Further, if the Universe is evolving, in what way is it changing? These are the fundamental problems of modern cosmology which have to be solved on the basis of observations. We will trace the historical development of this quest.

Modern cosmology, or the theories of the origin and evolution of the Universe, began with the discovery by the American astronomer Edwin Hubble in 1929 that the galaxies were receding and that the speed of recession increased proportionately with the distance of the galaxy. The proportionality, known as Hubble’s law, remained valid up to the farthest distances which could be

fathomed by the then largest 100-inch telescope. The obvious interpretation was that the Universe is uniformly expanding. A theoretical model for the expanding Universe had been put forward earlier in 1927 by the Belgian astronomer Abbé Georges Lemaître who obtained it as a solution of the equations of general theory of relativity formulated by Albert Einstein. The observations were represented by the Hubble’s constant $H = 550 \text{ km/s/million parsecs}$. This meant that the velocity of recession increased by 170 km/s for every million light years of distance. Extrapolating backwards it was found that all the galaxies would have been concentrated at one point some 1.8 billion years ago, which may be called the age of the Universe. According to the ideas of Lemaître, at that beginning epoch all the matter in the Universe was condensed in a super dense nucleus called the “primeval atom”. On account of the instability of matter in that dense state there was a rapid expansion, causing various fragments of that “primeval atom” to fly apart with tremendous speeds. These fragments later condensed into galaxies which continued to recede from one another. This is the “big bang” theory of the origin of the Universe.

The greatest problem with the “big bang” theory at that time was the small time scale it provided for the evolution of the stars and the planets. The geophysical data tell us that the oldest rocks on the surface of the Earth were formed about 3 billion years ago; the Earth itself must be older than this. The age of the Moon obtained from Darwin’s theory of tides and recent exploration of Moon rocks comes to about 4 billion years; and the age of the Sun derived from the rates of thermonuclear reactions in its interior would be between 4 and 5 billion years. Some of the meteorites are as old as 6 billion years. It would appear as though the parts of the Universe are older than the Universe itself. But this inconsistency was removed in 1950’s by a revision of the distance scale which was forced upon the astronomers due to some other considerations. According to the new yardstick the old distances had to be multiplied by a factor of 4 to 5. On

*This article is based on a radio talk by the author broadcast from All India Radio, Hyderabad.

making the necessary corrections the new value of the Hubble's constant is reduced to about 16 to 24 km/s/million light years, which gave about 12 billion years for the age of the Universe. We now have a long enough time scale for the formation of galaxies, stars and planets. Twelve billion light years is also the largest distance up to which we can see, because at that distance the speed of recession will equal the velocity of light; it is thus the limit of the visible Universe.

The constancy of the relative abundances of elements in all parts of our Galaxy and in other galaxies as well is cited as a proof of the "big bang" theory. The temperatures and pressures in the primeval atom of Lemaître would be extremely high. Under these conditions all protons and neutrons of the Universe would have coalesced to form a homogeneous nuclear fluid to which Gamow has given the name of "Ylum". Such a fluid would have been very unstable and it would explode with the slightest provocation. It was shown by the Indian-born American astrophysicist Subrahmanyan Chandrasekhar, Gamow and others that all the atoms in the Universe would be formed in the initial one hour or half of the explosion. Hence, the relative abundance of various kinds of atoms, which would be determined by the conditions of that first hour, would remain unchanged thereafter. What we observe today are these frozen abundances. However, there was a basic difficulty in producing elements heavier than helium.

Does the expansion of the Universe confer a unique position to our galaxy? The answer is an emphatic 'No'. The classical Newtonian as well as relativistic cosmologies require that there is no preferred position in space. The gross appearance of the Universe will be identical for any two observers; in particular all observers will experience the recession of galaxies from themselves. This is known as the cosmological principle. Can this principle be extended to the time coordinate as well? According to Gold and Bondi of Cambridge, England the aspect of the Universe should be the same not only to all observers at various points in space but also for the same observer at all times. This is

called the 'Perfect Cosmological Principle', which is the basis of the steady state theory of the Universe, postulated by Hoyle and the Indian astrophysicist Jayant Narlikar. According to it the overall properties of the Universe such as the mean density of matter and energy, the number of galaxies of various ages and luminosities in the observable Universe, etc., must remain unaltered with the passage of time. But the observations clearly show that the galaxies are receding and consequently the mean density of matter should decrease continuously. In fact the "big bang" theory envisages that the ultimate result of expansion will be an empty Universe. On the other hand, in order to compensate for the decrease in density continuous creation of matter in the form of hydrogen atoms is postulated in the steady state theory. The amount of new matter needed for this purpose is so minute that the instruments in our laboratories cannot detect its creation and hence the law of conservation of matter and energy need not be modified. The newly created matter would eventually condense into new galaxies. In this theory the Universe is ageless and everlasting.

It would seem that both "big bang" and steady state theories cannot account for the observed cosmic abundances of elements. But it was shown by William A. Fowler, Hoyle, Margaret Burbidge and others in 1960's that heavier elements can be formed by thermonuclear reactions in the interiors of stars. The observed relative abundances can be explained by considering the equilibriums of the various processes of this kind. In fact, this is the only way of producing elements heavier than helium.

In order to decide between the two theories we have to probe deeper into space. In this respect we can seek help from radio astronomy, which has brought to light several thousand discrete radio sources till date. Some of them have been identified with objects in our own galaxy and a few have been identified with distant peculiar galaxies. But the most discrete radio sources, which have remained unidentified, are undoubtedly very distant galaxies which are consequently too faint to be photographed with the largest optical

telescopes. A decision between the two theories can be made by a proper interpretation of their observed distribution in the sky. The problem is beset with several difficulties. But Martin Ryle and R.W. Clarke of Cavendish Laboratory claim that their observations definitely contradict the steady state theory. These conclusions have been tested and confirmed with more observations.

Two discoveries during the sixties have been crucial for cosmology. One is the discovery in 1963 of quasars, which are dense and massive star-like objects of very high luminosity, often exceeding the luminosity of entire galaxies. The quasars show large velocities of recession, approaching the velocity of light, which place them almost at the edge of the visible Universe. As these highly luminous objects seem to be concentrated in the remotest parts of the Universe, which is the same thing as saying that they were concentrated at the earliest epoch, they clearly indicate an evolution in the overall properties of the Universe as opposed to the unchanging steady state.

The other discovery, made in 1965, is that of an isotropic all pervading background radiation having an absolute temperature of 3K. This radiation is the remnant of the very high temperature radiation produced at the start of the big bang which has cooled to the observed low temperature due to expansion over a period of 12 billion years.

We can then assume that the 'steady state' theory is ruled out. However it does not automatically follow that the 'big bang' theory with a 'beginning' is correct. All that we can affirm is that the Universe is evolving. In fact the optical data obtained with the 200-inch telescope of Mount Palomar Observatory in USA, which doubled our depth of vision with respect to the older 100-inch telescope, as well as the count of radio sources observed with the most powerful radio telescopes, clearly indicate that the expansion of the Universe has not been uniform throughout. They indicated a deceleration of 5 to 10 km/s/million years for the remotest observed galaxies. Therefore the expansion cannot

(Contd. on page...18)



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Yogic exercises and Diabetes

Thanks to the modern day yogis, yoga camps and establishments, and the television and multimedia revolution, yoga has staged a major comeback and tops the popularity chart in the lucrative business of health and wellness.

The hard fact is that while several yogic exercises (*asanas*) can play a useful hand in lowering blood sugar, it is not a panacea or a cure-all. Several research studies have found that a regular practice of yoga has a beneficial effect on both the fasting and after-food blood sugar levels, but unless the disease is borderline, you may also require medications and moderation in lifestyle to preserve your blood sugar within a healthy range.

You would also do well to remember that you must practice yoga under trained guidance. A number of yogic *asanas* may not be advisable for people who have developed diabetes-related complications. For instance, *Sarvangha asana* is best avoided if you have suffered complications in the eye.

Here are a few yogic *asanas* which are particularly beneficial:

Lifting leg pose (*Uttanpada asana*)

Lie down on your back. Make the body straight. Keep the heels together. Bring the palms near the body on the mat. Relax and breathe freely. Stretch out the toes and make them hard and tight. Take a deep breath, and raise the legs upwards towards the sky, and gradually bring them into a perpendicular position. Hold this pose for a few seconds. Gradually increase the time to 10 seconds. While exhaling, return to the original position.

Caution: People who suffer from high blood pressure, coronary heart disease or backache should avoid this *asana*.

The serpent's pose (*Bhujanga asana*)

Lie down on the mat with the chest down. Keep the legs straight. Let the feet touch each other. The soles of the feet should touch face upwards. Keep the hands on two sides of the chest. Raise the head and stretch it back pushing your tongue out. Give a backward bent to the neck. Raise the chest slowly. Contract the muscles of the back. Give a backward bend to the back as much as possible. Experience a steady pull along the back from the neck downwards. After keeping the pose for a moment, lower the chest and relax the backbone. After brief relaxation, repeat the pose.

The locust pose (*Shalabh asana*)

Lie down on the mat on your stomach with chin touching the floor.

Keep your hands on the side of the body, with fingers straight and touching each other. Take a deep breath, and raise your right leg slowly, without a jerk. Maintain the posture for half a minute only in the beginning and gradually increase the time. Return to original position, relax and repeat with left leg. Next, raise both legs together. Do it two times only in the beginning.

The bow pose (*Dhanur asana*)

Lie down on your stomach. Keep your arms straight on both sides. Let your chin rest on the mat. Bring legs and heels together. Fold your legs at the knees. Bring the heels close to your hips. Grab the right ankle with your right hand, and the left with the left hand. Pull and stretch yourself upwards. Inhale, pause, exhale, pause.



Standing on the shoulders (*Sarvanga asana*)

Lie flat on your back with the muscles relaxed. Keep the hands alongside with thighs and legs together. Slowly raise the legs. Lift the back off the ground. Prop the back with the hands. The entire weight of the body should be balanced on the shoulders and the posterior part of the neck. Maintain this pose for a few seconds to begin with. Gradually increase the time to five minutes. Return to original position in slow motion.

The plough pose (*Hala asana*)

Lie flat on the ground. Stretch out the whole body. Make yourself quite straight. Bring the heels and the toes together. Lift your toes. Throw the legs forward. Bring the thighs above your head. Your arms will rest on the floor. Hold this pose for a few minutes. Inhale as you assume the pose; exhale as you return to the normal position. Synchronize the inhaling effort and lifting of legs.



The lotus pose (*Padma asana*)

Sit upright. Put the right foot on the left thigh, and the left foot on the right thigh. The heels come close to each other. The hands may be placed on the knees. Keep the eyes, the neck and the head straight. Inhale, hold breath, exhale, hold breath. You may spend one to 30 minutes in this pose, and meditate.

The fish pose (*Matsya asana*)

Sit in *Padma asana* by keeping the right foot over the left thigh and the left foot over the right thigh. Lie flat on the back. Stretch the head back. The top of the head should rest firmly on the ground, and so should the buttocks, thus making a bridge of the trunk. Place your hands on the thighs. Catch your toes with your hands. When you have performed the *asana* for a few minutes, slowly release the head with the help of hands. Sit up. Then unlock the *Padma asana*.

Yog mudra

Sit in the *Padma asana*. Place the palms on the heels. Exhale slowly. Bend forward and touch the floor with the forehead. Return to the original position and inhale. Instead of keeping the hands on the heels, you can take them back. Catch

hold of the left wrist with your right hand. Hold this pose for a few seconds.

Bending-the-back pose (*Paschimottana asana*)

Sit on the ground. Stretch your legs and arms stiff like a stick. Catch the toes with the thumb and index and middle fingers. While catching toes, bend the trunk forward. Exhale. Slowly bend without



jerks till your forehead touches your knees. When you bend down, draw the belly back. Retain the breath till you take the forehead back to its original position. Inhale. If you find it difficult to do full *Paschimottana asana*, you could begin by doing the half pose with one leg and one hand and then with the other leg and the other hand. Once the spine becomes more elastic, you can do the full pose.

Caution: If you suffer from sciatica or bad joints, avoid doing this *asana*.

Pranayama

Pranayama is the yoga of breathing. It has three stages: exhalation, inhalation, and retention of breath. The technique is simple. Sit on the ground in lotus or easy pose. Hold the spine, neck and head absolutely upright. Look straight. Stretch your arms and rest your wrists on the knees. Bring your thumb and index finger in apposition so that they form a circle. Keep the other three fingers straight. Breathe normally.

Now, exhale slowly through both nostrils and at the same time, contract your abdominal muscles to expel air from the lungs. Pause for a second. Next, inhale as deep as you can, sucking air through the nose, and letting it fill all the vessels in the body. The abdominal muscles should also expand this time. Pause for a second. Repeat exhalation. Continue the same process ten or fifteen times.

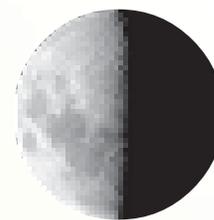
Sky Map for September 2007

Full Moon



27 September

Moon - Last Quarter

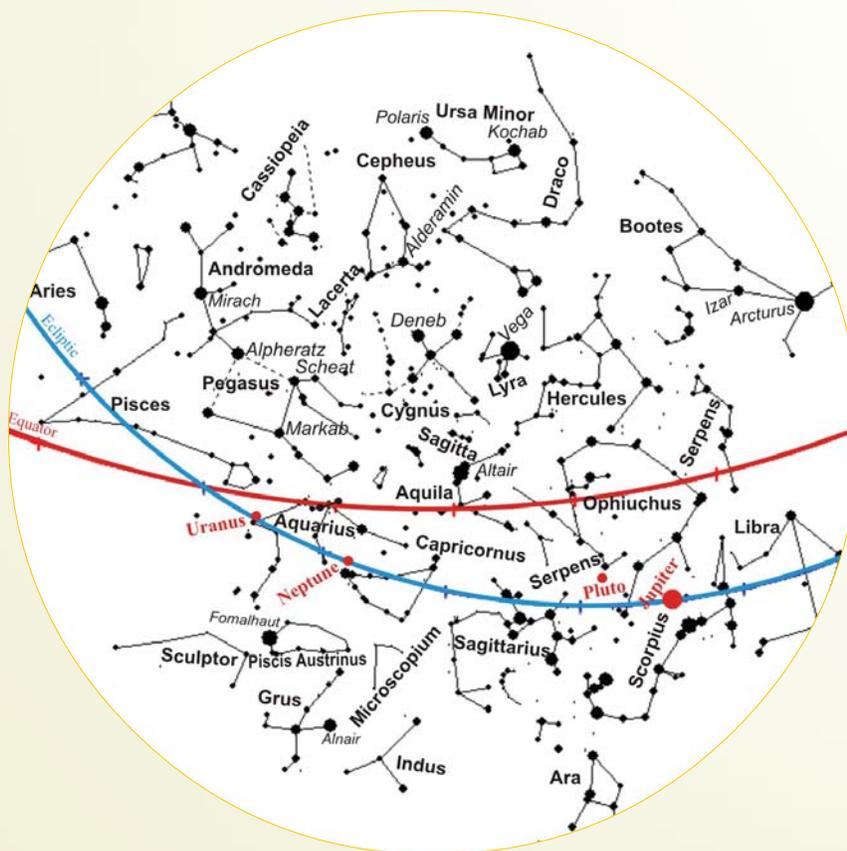


4 September

North

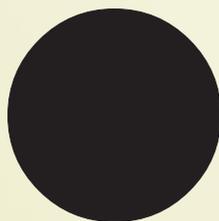
East

West



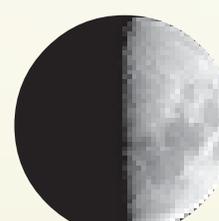
South

New Moon



11 September

Moon - First Quarter



19 September

The sky map is prepared for viewers in Nagpur (21.09° N, 79.09° E). It includes bright constellations and planets. For viewers south of Nagpur, constellations of the southern sky will appear higher up in the sky, and those of the northern sky will appear nearer the northern horizon. Similarly, for viewers north of Nagpur, constellations of northern sky will appear higher up in the sky, and those of the southern sky will appear nearer the southern horizon. The map can be used at 10 PM on 1 September, at 9:00 PM on 15 September and at 8 PM on 30 September.

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:

- Jupiter:** In the constellation Ophiuchus near South western horizon.
- Uranus:** In the constellation Aquarius (*Kumbha Rashi*) up in the South eastern sky*.
- Neptune:** In the constellation Capricornus (*Makar Rashi*) up in the Zenith Sky*.
- Pluto:** In the constellation Sagittarius (*Dhanu Rashi*) up in the South western sky*.
- (* Are not naked sky objects.)

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

- Eastern Sky :** Andromeda/*Devayani*, Aquarius/*Kumbha Rashi*, Aries (Hamal) / *Mesha Rashi*, Pegasus, Pisces/*Meen Rashi*.
- Western Sky :** Bootes (Arcturus)/(*Swati*), Hercules, Libra/*Tula Rashi*, Ophiuchus, Serpens.
- Southern Sky :** Ara, Capricornus/*Makar Rashi*, Grus, Indus, Microscopium, Piscis Austrinus (Fomalhaut), Sagittarius/*Dhanu Rashi*, Sculptor, Scorpius (Antares)/*Vrischik Rashi (Jeshta)*.
- Northern Sky :** Cassiopeia, Cepheus, Draco, Lacerta, Ursa Minor (Polaris)/*Dhurva Matsya (Dhurva Tara)*.
- Zenith :** Aquila (Altair)/(*Sravana*), Cygnus (Deneb)/*Hansa*, Lyra (Vega)/*Veena (Abhijeet)*, Sagitta.

□ Arvind C. Ranade

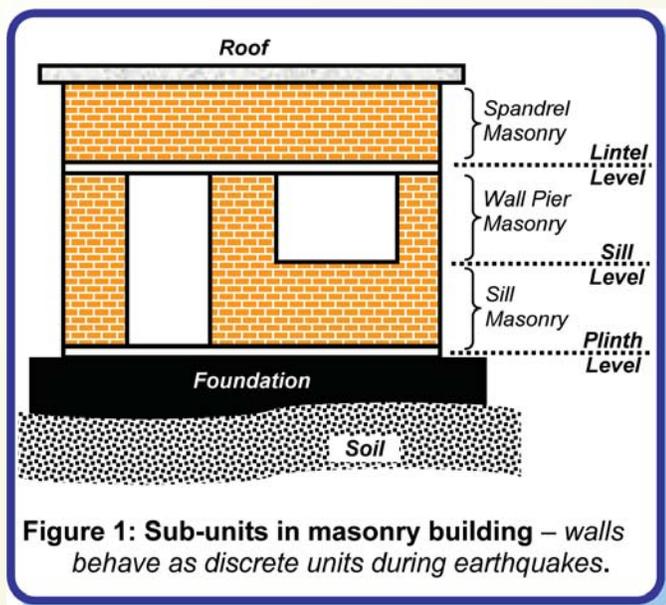
E-mail : rac@vigyanprasar.gov.in

Earthquake Tip-15

Why is vertical reinforcement required in masonry buildings?

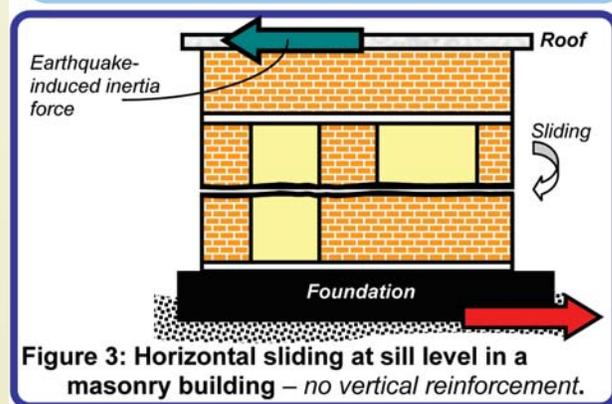
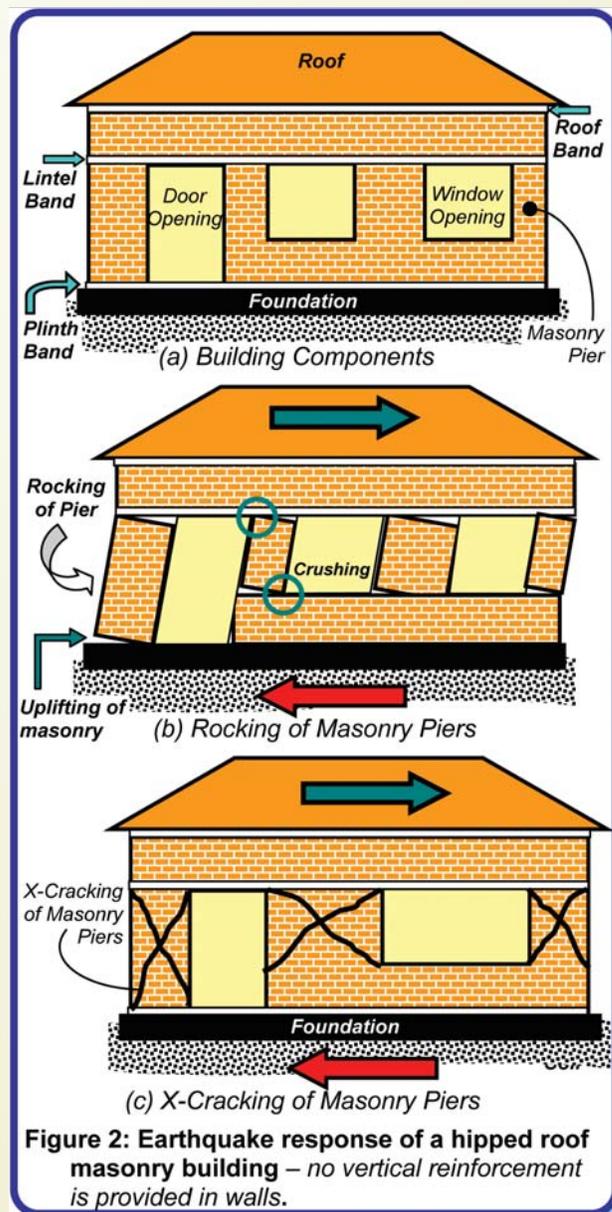
Response of Masonry Walls

Horizontal bands are provided in masonry buildings to improve their earthquake performance. These bands include 'plinth band', 'lintel band' and 'roof band'. Even if horizontal bands are provided, masonry buildings are weakened by the openings in their walls (Figure 1). During earthquake shaking, the masonry walls get grouped into three sub-units, namely 'spandrel masonry', 'wall pier masonry', and 'sill masonry'.



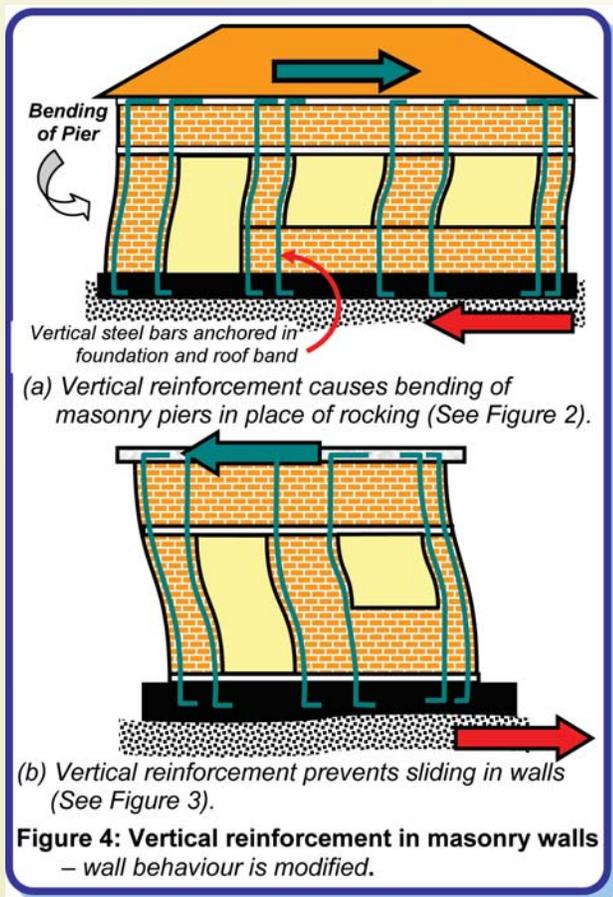
Consider a hipped roof building with two window openings and one door opening in a wall (Figure 2a). It has 'lintel' and 'plinth bands'. Since the roof is a hipped one, a roof band is also provided. When the ground shakes, the inertia force causes the small-sized masonry wall piers to disconnect from the masonry above and below. These masonry sub-units rock back and forth, developing contact only at the opposite diagonals (Figure 2b). The rocking of a masonry pier can crush the masonry at the corners. Rocking is possible when masonry piers are slender, and when weight of the structure above is small. Otherwise, the piers are more likely to develop diagonal (X-type) shear cracking (Figure 2c); this is the most common failure type in masonry buildings.

In un-reinforced masonry buildings (Figure 3), the cross-section area of the masonry wall reduces at the opening. During strong earthquake shaking, the building may slide just under the roof, below the lintel band or at the sill level. Sometimes, the building may also slide at the plinth level. The exact location of sliding depends on numerous factors including building weight, the earthquake-induced inertia force, the area of openings, and type of doorframes used.



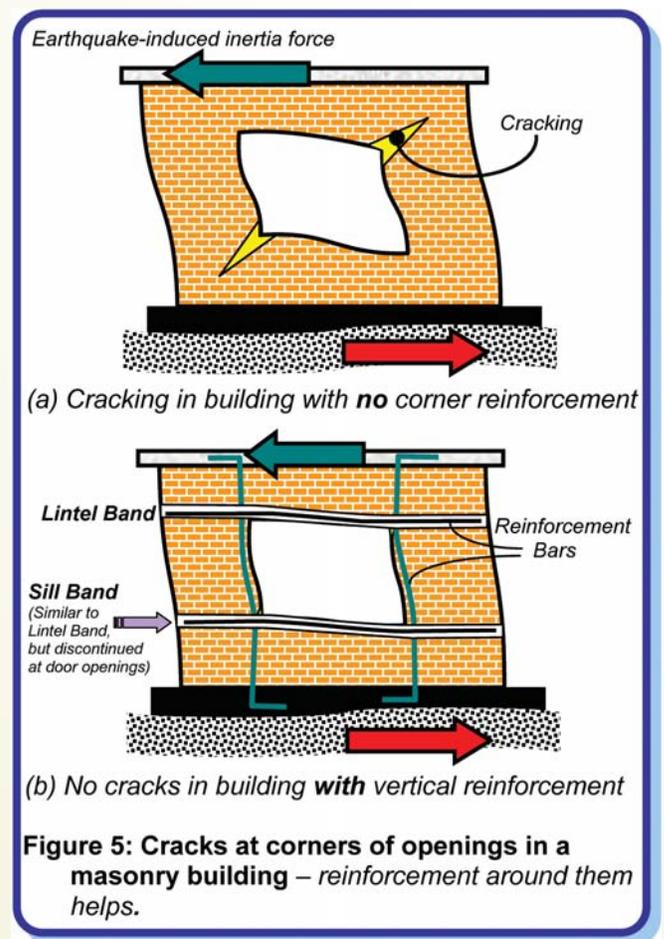
How Vertical Reinforcement Helps

Embedding vertical reinforcement bars in the edges of the wall piers and anchoring them in the foundation at the bottom and in the roof band at the top (Figure 4), forces the slender masonry piers to undergo bending instead of rocking. In wider wall piers, the vertical bars enhance their capability to resist horizontal earthquake forces and delay the X-cracking. Adequate cross-sectional area of these vertical bars prevents the bar from yielding in tension. Further, the vertical bars also help protect the wall from sliding as well as from collapsing in the weak direction.



Protection of Openings in Walls

Sliding failure mentioned above is rare, even in unconfined masonry buildings. However, the most common damage, observed after an earthquake, is diagonal X-cracking of wall piers, and also inclined cracks at the corners of door and window openings. When a wall with an opening deforms during earthquake shaking, the shape of the opening distorts and becomes more like a rhombus – two opposite corners move away and the other two come closer. Under this type of deformation, the corners that come closer develop cracks (Figure 5a). The cracks are bigger when the opening sizes are larger. Steel bars provided in the wall masonry all around the openings restrict these cracks at the corners (Figure 5b). In summary, lintel and sill bands above and below openings, and vertical reinforcement adjacent to vertical edges, provide protection against this type of damage.



Related IITK-BMTPC Earthquake Tip

- Tip 5 : What are the seismic effects on structures?
- Tip12 : How brick masonry houses behave during earthquakes?
- Tip13 : Why masonry buildings should have simple structural configuration?
- Tip14 : Why horizontal bands are required in masonry buildings?

Resource Material

1. Amrose, J., (1991), *Simplified Design of Masonry Structures*, John Wiley & Sons, Inc., New York, USA.
2. BMTPC, (2000), *Guidelines: Improving Earthquake Resistance of Housing*, Building Materials and Technology Promotion Council, New Delhi.
3. IS 4326, (1993), *Indian Standard Code of Practice for Earthquake Resistant Design and Construction of Buildings*, Bureau of Indian Standards, New Delhi.
4. IS 13828, (1993), *Indian Standard Guidelines for Improving Earthquake Resistance of Low-strength Masonry Buildings*, 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

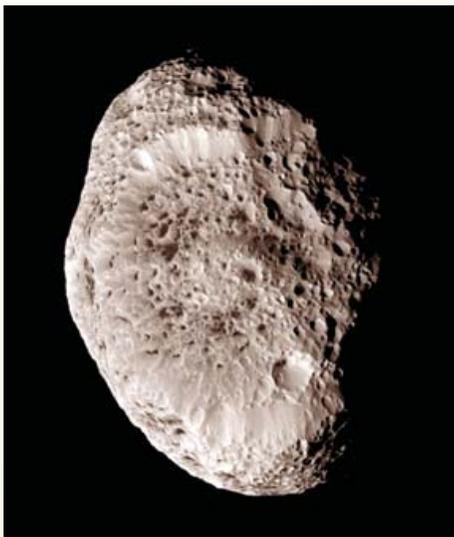
Recent Developments in Science and Technology

□ Biman Basu

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Saturn's sponge-like moon

Saturn's moon Hyperion is unlike many other planetary moons. Measuring some 400 km by 260 km by 220 km, it is the largest non-spherical body in the Solar System. It was discovered in 1848



Saturn's sponge-like moon Hyperion

independently by the American astronomer George Phillips Bond and the English astronomer William Lassell. Till recently, Hyperion was believed to be composed primarily of water ice with only a small amount of rocky material. But analysis of data returned by NASA's *Cassini* spacecraft has now revealed, for the first time, surface details of the moon, which show cup-like craters filled with hydrocarbons, giving it a sponge-like appearance. The presence of hydrocarbons may indicate a more widespread presence in our solar system of basic chemicals necessary for life (*Nature* 5 July 2007).

The information was gathered by *Cassini's* ultraviolet imaging spectrograph and visual and infrared mapping spectrometer as the spacecraft flew close by the moon in September 2005. Hyperion's surface craters and composition were observed during this flyby. The

spacecraft's instruments found that most of the surface is a mix of frozen water and trace amounts of frozen carbon dioxide, as well as dark material that fits the spectral profile of hydrocarbons. The discovery of hydrocarbons is significant because when these molecules are embedded in ice and then exposed to ultraviolet radiation, new complex molecules of biological significance may be formed. This is the first time scientists have been able to map the surface material on Hyperion.

Besides providing surface data, *Cassini* also helped scientists work out why Hyperion has such a bizarre spongy appearance. According to them, it all comes down to an extremely low density. According to the scientists, Hyperion has only half the density of water. Its low gravity means that normal processes, such as crater formation work differently than on more dense objects in the Solar System. Objects that impact Hyperion plunge in, compressing the surface, instead of blasting out the familiar looking craters.

Vaccinating with rice

Vaccination against cholera always involved the painful jab of a needle. But now Japanese researchers at the University of Tokyo have developed a novel vaccine for cholera – a genetically modified variety of rice that can be administered by mouth (*Proceedings of the National Academy of Sciences*, 26 June 2007). Since the rice-based vaccine comes from an edible plant, it is safe and inexpensive to produce in large quantities. What is more, the genetically modified rice can be stored at room temperature for at least a year and a half; so there is no problem of maintaining the cold chain, as is necessary with many of today's vaccines. It is estimated that worldwide, it costs Rs.8,000 million to 12,000 million each year to preserve vaccines at cold temperatures. Rice also

has greater protein content than some of the starch-based edible vaccines currently under experimentation for a variety of infectious diseases. Another advantage of an oral vaccine is that, abolishing the painful use of needles and syringes not only cuts costs, but also prevents pathogens from accidentally appearing in the vaccines and then spreading throughout the population, especially in underdeveloped countries where supplies are limited.

Cholera is a bacterial disease that affects the intestinal tract. It is caused by the bacterium *Vibrio cholerae* and is transmitted to humans through contaminated food and water. Cholera is prevalent in African and Latin American countries and parts of Asia including India, and worldwide the number of cases has risen almost 30 percent since 2004, according to the World Health Organization. If untreated, the disease can be fatal.

To create the rice-based cholera vaccine, the Japanese researchers isolated the genetic material from the cholera bacterium and inserted it into the sequenced genome of two local varieties of rice plant. Once the rice plants produced the toxins, the modified rice in a powder form suspended in water was fed to mice. The rice-based vaccine produced antibodies in the mice's bodies, especially in the mucosal layers of the intestine, which are most prone to damage by the cholera bacterium. As a result, the mice became immune to the diarrhoea-causing bacterium. The researchers plan to prepare the rice-based vaccine in the form of a capsule or tablet for applications in humans.

Bacteria species transformed by genome swapping

The genome is the complete collection of hereditary information (DNA) for an individual organism that characterises a species. It has been known ever since Oswald Avery's pioneering experiments with pneumococcal transformation more than six decades ago, that some bacteria can take up naked DNA. Working on the pneumococcus bacteria that cause

pneumonia, Avery and his team in the 1930s had discovered that the so-called “transforming principle” that transformed harmless pneumococcus bacteria into infectious one was nothing but pure DNA. In Avery’s experiment, this DNA was generally degraded or recombined into the recipient chromosomes to form genetic recombinants. Now Carole Lartigue and co-workers at the J. Craig Venter Institute in Maryland, USA, have taken DNA from a bacterium called *Mycoplasma mycoides* and inserted it into cells of the closely related species *Mycoplasma capricolum*, and found that the recipient cells with the new genome behaved exactly like those of the donor species, making protein molecules characteristic of the donor. In other words, they have been able to transform one species into another (Science Express online publication, doi:10.1126/1144622, 2007).

To swap the genomes, the researchers first encased *M. mycoides* cells in a gel and used enzymes to break them apart and destroy their proteins, leaving only their naked DNA. Then they mixed this DNA into colonies of *M. capricolum* and added a chemical that makes cells fuse together. Some of the

recipient cells probably fused around the naked donor genomes, producing cells with DNA of both species. During division of the hybrid cell one genome ended up in each daughter cell. To isolate the cells with the donor genome, the mixture of cells was treated with a dose of a specific antibiotic killed off all the cells without the donor genome.

The work raises the possibility of reprogramming cells with new functions, maybe even turning cells from other organisms into human stem cells for regenerative medical treatments, in the distant future. At present the research team is working on giving a bacterium a completely synthetic genome, made in the laboratory, which could in future make it possible to design a new species from scratch.

New way to kill antibiotic-resistant bacteria

Antibiotic-resistance is a major problem faced by the medical community today. Indiscriminate and unrestricted use of antibiotics is a major factor in development of resistance in pathogenic bacteria, which become immune to common antibiotics and require more powerful antibiotics to control. Now researchers at the

University of North Carolina (UNC), USA, have come up with a technique of gene swapping that could stop the spread of drug-resistant bacteria (online edition of *Proceedings of the National Academy of Sciences*, 9 July 2007).

Bacteria are known to spontaneously transfer to each other strands of DNA – a process known as ‘conjugation’. In fact, this is how they pass on survival advantage, including resistance to antibiotics. An enzyme called relaxase helps them do this. The UNC team has discovered that the action relaxase can be blocked by drugs called bisphosphonates, which are already approved as a treatment for bone loss. Once the enzyme is blocked, the researchers found, antibiotic resistance genes cannot spread. Interfering with the enzyme has the added effect of annihilating antibiotic-resistant bacteria in laboratory cultures.

The researchers have worked only with *Escherichia coli* so far, but will shortly be testing to see if bisphosphonates have the same effect on other species such as *Acinetobacter baumannii* (hospital-acquired pneumonia), *Staphylococcus aureus* (staph infections) and *Burkholderia* (lung infections). ■

(Contd. from page...25) The Origin of the Universe

continue indefinitely and the result will be an eventual contraction which may be followed again by expansions and contraction in a cyclic order. The period of the cycle was estimated by the American astronomer Allan Sandage to be about 80 billion years. This was the situation in 1970’s.

Here again there is an observation difficulty. The expansion of the Universe can be stopped only by the self-gravitation of all the mass contained within it. It is estimated that for gravitation to prevail over expansion the mean density of matter in the Universe should be at least 10^{-29} g/cc. But actually the density, obtained by spreading all the observed matter in the galaxies throughout the intergalactic space,

comes to only a few per cent of the required density. Hence for reconciling the observed deceleration of the Universe we have to postulate that there ought to exist a large amount of invisible matter in the Universe in the form of black holes, neutron stars, white dwarfs, planets and even ordinary rocks. The search for missing matter was facilitated by the launch of the Hubble Space Telescope in 1990’s. As the obstruction the Earth’s atmosphere is eliminated it is possible to observe much farther in deep space in all wavelengths from gamma rays to radio waves. It is now found that the Universe is not only expanding but also accelerating in expansion. Also it has been possible to detect the presence of dark matter. Further it has been found that the

Universe also contains dark energy which is responsible for the observed acceleration. However, the earliest epochs immediately after the big bang are still out of reach and need further probing. Then only will it be possible to know the original cause of the big bang.

We may end this review by the almost sceptical question posed in the Nasadiya Sukta of Rigveda. It says: “Who knows and who can tell from where this Universe sprang up and where it will end? Perhaps the Purveyor of all, who resides in the most elevated space, may know it! Perhaps he may not know it either!”

Prof. K.D. Abhyankar is a well-known astrophysicist and science popularizer. He lives in Hyderabad and can be contacted at Flat G-3, Shubha Tulsi, 12-13-625, Tarnaka, Secunderabad 500 017. ■

A Video Film on Prof. Babulal Saraf

Vigyan Prasar jointly with the Inter University Accelerator Centre (IUAC) has produced a video film "Babulal Saraf: Master Experimentalist". The Centre for Development of Physics Education, University of Rajasthan, Jaipur actively supported the production of the film. The film is directed by Sunil Shanbag and has been produced by Chrysalis Films, Mumbai. Even though mainly biographical, the film also highlights the inspirational elements, like what kept Prof. Saraf pursuing this line of work. It also demonstrates how equipment used for demonstrating the experiments can be fabricated with locally available resources with some ingenuity. Prof. Saraf significantly changed the way physics was taught in colleges.



(From R to L) Dr. Amit Roy, Dr. V. B. Kamble, Prof. Babulal Saraf, Prof. Yash Pal, Prof. N. K. Jain

the objective behind making the film and the roles played by their respective organisations. Prof. B. K. Sharma, Director, CDPE, University of Rajasthan, Jaipur gave the vote of thanks. The release function

was attended by a large number of eminent scientists, research students and science communicators. A number of former students of Prof. Saraf attended the function.

The film has been produced in two versions. The 24-minute version will be broadcast on TV channels and the longer version (45-minute), which contains more experiments in detail, will be utilised in schools and colleges.

This film is part of series of bio-

graphical video films on eminent scientists, science educationalists and science communicators produced by Vigyan Prasar jointly with different scientific institutions. It has already produced films on G. N. Ramachandran, P. C. Mahalanobis, A. K. Raychaudhuri, P. C. Vaidya, A. R. Rao, Raja Ramanna, and Prof. Yash Pal.



A section of the audience

The film was released by Professor Yash Pal, Chancellor of the Jawaharlal Nehru University on 11 July 2007 at IUAC, New Delhi. Professor Babulal Saraf himself graced the occasion. Professor N. K. Jain, Vice-Chancellor, University of Rajasthan, Jaipur received the first copy of the film. Dr. Amit Roy, Director, IUAC and Dr. V. B. Kamble, Director, Vigyan Prasar in their opening remarks mentioned

'Science Activity Summer Camp 2007'

Vigyan Prasar and National Rail Museum (NRM) jointly organised two 'Science Activity Summer Camps' on the theme 'Planet Earth' during 12-24 June 2007 at the National Rail Museum, Delhi. More than 250 students in the age-group of 10 to 16 participated in the camp. The aim of the summer camp was to explore new dimensions of Science through practical knowledge by doing hands-on activities. The response of the children was very encouraging. During two workshops of six days each, lectures, demonstration and a number of hands-on activities were conducted by resource persons, majority of them by the scientists and other officials of Vigyan Prasar. Activities conducted during the camp included 'Exploring Nature', 'Understanding Earth through Puppet Drama', 'Fun with Plants in Soil-less Condition', 'Detection of Food Adulteration', 'Scientific Explanations of so-called Miracles', 'Making of Scientific Kits & Folk Toys using Waste and Low-cost Material', and 'Interactive Sessions on Astronomy and Sky Watching'. A similar camp was organised by VP jointly with Rail Museum during the summer vacations last year.

Letters to the Editors

It is nice after receiving *DREAM 2047*, June 2007 issue. I am proud that we are getting a wonderful scientific magazine in India that can be enjoyed not only by children but also by all science lovers. Regarding incandescent bulbs (Editorial), although more energy-efficient, could a poor family afford LEDs or CFLs? In my view government should subsidise these energy-efficient bulbs.

I am again requesting you for to increase the number of pages so that more articles can be accommodated, which would make the journal more informative.

Anup Pattanaik

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