

Monthly Newsletter of Vigyan Prasar



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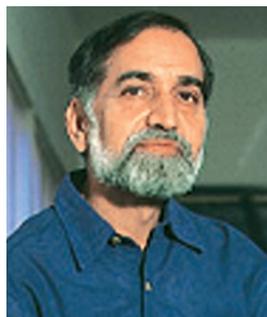
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VP News

Shri Kiran Karnik takes over as President of Vigyan Prasar



Shri Kiran Karnik

Shri M. V. Kamath completed his tenure as the President of the Vigyan Prasar Society recently. He has been a source of inspiration to many of the initiatives of Vigyan Prasar. In particular, he was the guiding force behind the "Vigyan Rail - Science Exhibition on Wheels" that proved to be a landmark in the history of



Shri M.V. Kamath

Science and Technology Communication in the country. He has been one of the seniormost journalists of the country and was awarded Padma Vibhushan for his services to the country. We shall continue to benefit through his ideas and guidance in the years to come, we are sure.

Vigyan Prasar welcomes Shri Kiran Karnik, President, NASSCOM, as its new President. A pioneer in the field of Information and Communication Technology, he was with the Indian Space Research Organisation (ISRO) for over 20 years, where he held various positions related to conception, planning, and implementation of applications of space technology, focussing on the use of communication for development. He was a key member of the management team of the Satellite Instructional Television Experiment (SITE) that ushered in the era of satellite communication in the country in 1975-1976. Shri Karnik briefly worked with United Nations in New York and Vienna serving as the Special Assistant to the Secretary-General of UNISPACE-82.

He was Director, Development and Educational Communication Unit, ISRO, Ahmedabad, during the period 1983-1991. Shri Karnik joined the Inter-University Consortium for Educational Communication (now Consortium for Educational Communication), UGC, as its first Director in 1991. He was the Managing Director of the Discovery Networks in India from 1995 - 2001, and spearheaded the launch of the Discovery Channel in South Asia in August 1995, and of Animal Planet (a Discovery- BBC joint venture) in 1999. At present, Shri Karnik is the President, National Association for Software and Service Companies (NASSCOM). In 1998, he was awarded the Frank Malina medal for Space Education by the International Astronautical Federation.

Shri Kiran Karnik has been associated with the activities of VP as a member of its Governing Body ever since the inception of VP. There is no doubt, under his leadership, Vigyan Prasar will attain even greater heights in its endeavour of taking science to the people.

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

In Search Of Pleasure – From Caffeine to Cocaine

The consumption of drugs for recreation and pleasure is deeply rooted in our culture and history. There are numerous references to the use of wine (*sura* and *soma*) and opium (*ahiphena* or *aphena*) ever since the Vedic times. In the Mahabharata, there are several allusions to consumption of alcohol. Sushruta has listed several hundreds of plant drugs including anaesthetics, poisons, spices, and narcotics. Consumption of alcohol over dinner parties does not raise any eyebrows now-a-days. Alcohol is a simple molecule, but a complex drug. Alcohol is used in many medicinal preparations and may be a welcome antidote to stress. It may give rise to pleasurable feelings, but it also acts as a depressant. Yet another reference to a recreation drug we come across in ancient literature is the notorious plant of opium poppy. Opium is the reddish-brown heavily scented addictive drug prepared from the dried juice of unripe pods of the poppy flower, which is used in medicine as an analgesic and a narcotic. While morphine is derived from this plant, heroin is a synthetic derivative of morphine. Heroin can be smoked, snorted or dissolved in water and injected. Over time the desired effects reduce so users have to take more to have the same effect. Heroin users are generally pitied – it is assumed that they must have an addiction problem.

Most of us take caffeine in the morning coffee or tea – the cuppa that cheers and stimulates, and there is no social stigma attached to it. Indeed, caffeine is the most widely consumed stimulant, the most popular, and the safest of the recreational drugs. It is the main ingredient of tea, coffee, and chocolate, and is found in over 100 plant species. Coffee contains 100 milligrams of caffeine per average cup – about twice as much as a cup of tea. A small chocolate bar contains as much stimulant as a cup of tea. It is interesting to note that the average half-life of caffeine in the body is about 5-6 hours. This is why some of us experience a sleepless night if we take coffee after dinner. Caffeine may increase heart rate, and produce palpitations, and hence could cause needless anxiety. It may be interesting to note that extracts of the caffeine containing nuts *Cola acuminata* and *Cola nitida* are the active ingredients of the popular soft drinks Coca Cola and Pepsi.

Cocaine is a more powerful stimulant than caffeine – but not so benign. Cocaine is an extract of coca plant. Like caffeine, cocaine also has been in use for centuries. The German chemist Albert Niemann synthesized pure cocaine in 1860 and it was initially used as an anaesthetic. Cocaine is a potent central nervous system stimulant and makes the user feel euphoric and energetic. Gradually the user becomes more and more dependent on the drug. Common health effects of chronic use include heart attack, respiratory failure, stroke, and seizures. Cocaine is a strong addictive drug, the variations

of which can be chewed, snorted, injected or smoked. 'Crack' is cocaine processed for smoking.

Coca Cola when first introduced in 1886 originally contained cocaine. But soon after the addictive properties of cocaine were realized in the early 20th century, it was removed from the drink and replaced with more caffeine. Sigmund Freud, the fountainhead of psychoanalysis, was an early user and extoller of the virtues of cocaine! Robert Louis Stevenson is said to have written *Dr. Jekyll and Mr. Hyde* in six days and nights on a cocaine binge! Incidentally, Peru is the largest producer of coca paste and leaf, while Colombia is the largest producer of the finished product – cocaine.

Amphetamines (also known as 'speed') are chemically made stimulant drugs. Their short-term effects include feeling of mental stimulation, emotional warmth, and increased physical energy. Amphetamines were issued to combat troops in World War II to keep them fighting in the absence of food. Amphetamines can be sniffed through a narrow tube, but can be prepared for injection, swallowed in a drink, or smoked with tobacco. Heavy use of amphetamines can cause a mental illness called psychosis where people report seeing, feeling or hearing things that are not really there, and can also induce suicidal tendencies. Rush of a stimulant is generally followed by a crash into depression.

Among the most widely used psychedelic drugs are cannabis, Ecstasy, and LSD (lysergic acid diethylamide). Their use has been on the rise in the party circuits, especially in the age group 25-35 years despite legal restrictions. Psychedelics produce hallucinations. One is likely to experience distortions of perceptions. The colour of a leaf may seem exceptionally intense, or extraordinary images and patterns may be seen behind closed eyes, and the sense of time and place may get altered. Cannabis is a plant (also known as hemp) that is also cultivated in many parts of the world. The flowering head of the female plant produces most of the resin that contains the psychoactive constituents. Cannabis is usually smoked, or consumed with food or in a drink. It is a depressant drug with hallucinogenic properties. Marijuana and hashish are also obtained from this plant. Incidentally, marijuana is the most commonly used illegal drug in the world. Ecstasy is a synthetic psychoactive drug, which comes in the form of pills and acts both as a stimulant and psychedelic. It produces an energizing effect as well as distortions in time and perception. LSD is synthesized from alkaloids found in ergot, a fungus that attacks cereal crops. It was first synthesized by the Swiss chemist Albert Hofmann who discovered the hallucinogenic properties by accident. LSD alters experience of senses, emotions and awareness.

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Emmy Noether

The Greatest Woman Mathematician

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“She (Noether) was one of the leading figures in the development of abstract algebra, working on ring theory and the theory of ideals. The theory of Noetherian rings has been an important subject of later research, and she developed it to provide a neutral setting for problems in algebraic geometry and number theory.”

Chambers Biographical Dictionary (Centenary Edition)

“The memory of her work in science and of her personality among her fellows will not soon pass away. She was a great mathematician, the greatest, I firmly believe, her sex has ever produced, and a great woman.”

Hermann Weyl's remarks at Noether's funeral

Emmy Noether's most important contributions to mathematics were in the area of abstract algebra....Her work was original and creative, and inspired her successors in abstract algebra to create a 'Noether School.'

The Cambridge Dictionary of Scientist (2002)

Emmy Noether was one of the most creative and original mathematicians of the world. The German-born American mathematician and mathematical physicist Hermann Weyl (1885-1955) called her the greatest woman mathematician. Commenting on her ability as a mathematician, Albert Einstein (1879-1955) said: “In the judgement of the most competent living mathematicians, Fraulein Noether was the most significant mathematical genius thus far produced since the higher education of women began. In the realm of algebra in which the most gifted mathematicians have been busy for centuries, she discovered methods, which have proved of enormous importance in the development of the present day younger generation of mathematicians. She worked in the realm of most abstract (or 'coldest' as some people would like to call) algebra. Discussion on her mathematical work is beyond the scope of this article. Her work was of fundamental importance in the development of modern algebra. She was able to find relationships that traditional algebraists could not.

Noether's conceptual approach to algebra generated a body of principles, which helped to unify algebra, geometry, linear algebra, topology and logic. Her works were basic to the general theory of relativity and elementary particle physics. Her work on invariants and her transformation theorem clarified connection between symmetries and constants of the motion in dynamical systems. Her theorem was crucial in modern quantum field theory. She published about 45 research papers. Her student B. L. van der Waerden wrote a two-volume book titled *Modern Algebra* in which a major part of the second volume consisted of

Noether's work. Noether helped edit the famous mathematical journal *Mathematische Annalen*. She inspired the formation of the so-called “Noether school.” Her work in algebra was considered controversial. Her approach to algebra was conceptual. At that time it was a debatable point whether ‘mathematics should be conceptual and abstract or more physically based and applied (constructionist).’

Noether truly loved mathematics. She had an uncanny power to influence and stimulate people around her. As Hermann Weyl said, ‘she possessed a rare humour and a sense of sociability.’ She did not take part in political activities. She was a pacifist.

Emmy Noether was born on 23 March 1882 in Erlangen, Bavaria, Germany. Her name was Amalie but she is always known as Emmy. Her father Max Noether was a professor of mathematics at the University of Erlangen and her mother Ida Amalia (*nee*

Kaufmann) came from a wealthy family of Cologne. Her father was a distinguished mathematician specialising in algebraic geometry. Her mother was a musician. Both of her parents were of Jewish origin.

Emmy was an average child. In her childhood, she did not display any extraordinary talent in mathematics or a deep liking for it. She studied at the Municipal School for the Higher Education of Daughters. In 1900, at the age of 18, she took the Bavarian State Examination to be qualified to become a certified teacher in French and English at Institutions for the Education and Instruction of Females (in other words girls' schools in Bavaria). Although she became a certified teacher for language teaching she never taught



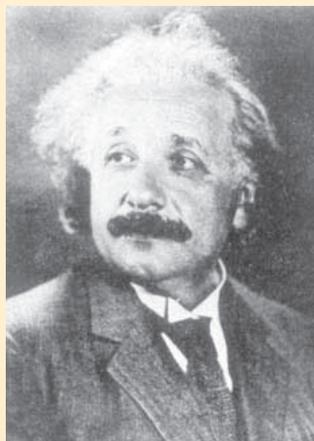
Emmy Noether

languages. Instead she decided to study mathematics. There is no doubt that in choosing a career in mathematics she had been influenced by the 'mathematical atmosphere' in her home. Following the influence of her father her brother Fritz had taken up mathematics as a career. As one of her biographers Lynn M. Osen wrote: "If the ambience of her home had been different, she might have never chosen a career in mathematics, but the provocative discussions that swooped and soared around the young Emmy had sparked an interest that was overpowering."

Emmy had to overcome a lot of hurdles in her way to become a student of mathematics. Being a woman, it was not easy for her to get admission into a university. In Germany women were not permitted to enter universities till 1900. Instances of women taking university examinations were very rare. In a resolution passed in 1898, the Academic Senate of the University of Arlangen declared that admitting women students to the university would mean overthrowing all academic order. It was true that women were allowed to study in the German universities but then each professor had to give permission separately. Women were not allowed to attend a secondary school for completing the preparatory course for admission in a university. However, they were allowed to take the matriculation examination.

Noether got permission to attend courses at the university from 1900 to 1902. In 1903, she passed the matriculation examination in Nuberg. After passing the matriculation examination, She went to the University of Gottingen, where she attended lectures by David Hilbert (1862-1943), Christian Felix Klein (1849-1925), and Hermann Minkowski (1864-1909). The University of Göttingen had liberal policies towards women students. The University of Erlangen started permitting women students to enrol in the year 1904. Thus Emmy returned to Erlangen and she started working under the supervision Paul Gordan. In 1908 she was awarded a PhD degree. Her dissertation for PhD degree was "On Complete Systems of Invariants for Ternary Biquadratic Forms." After completing her PhD, she remained at the Erlangen University for the next seven years. She had no appointment. She mostly spent the time by doing research in mathematics. She worked with Ernst Fischer. While at the Erlangen University, she also helped her father by teaching his classes when he was sick.

In 1915, Noether was invited by Felix Klein and David Hilbert to join the mathematical institute at the Göttingen University. There was a specific reason for this. They thought



Albert Einstein

Noether's work would complement their work on Einstein's theory of relativity. Many members of the university faculty were opposed to allowing a woman to join the faculty. Hilbert wanted a regular appointment for Noether or at least a "habilitation", enabling her to become a "privatdozent". It has been reported that the opponents expressed their concerns in the following words. "How can we permit a woman to become a privatdozent? Having become a privatdozent, she can then become a professor and a member of the university senate. Is it possible that a woman can enter the senate?" They were also supposed to have posed the question: "What will our soldiers think when they return to the university and find that they

are expected to learn at the feet of a woman?" Against these observations Hilbert is supposed to have answered: "I do not see that the sex of the candidate is against her admission as a privatdozent. After all, the university senate is not a bathhouse." Hilbert and others failed to convince the faculty to offer a regular appointment to Noether. However, Noether was allowed to give lecture under Hilbert's name,

as his assistant. In 1919, she was made a privatdozent. She was allowed to lecture in her own name but no remuneration was paid for her work. Even this was possible because of Hilbert's and Einstein's recommendations.

In 1922, Noether became an "Associate Professor without tenure." She was officially entitled to teach, give examinations, and direct dissertations. She established

a high reputation of an exceptional mathematician. However, her status at the university remained same. She was not made a proper faculty member. Whatever might be her status in the faculty, she spent the time at Göttingen usefully by teaching, discussing and doing mathematical research. Though she was not given a regular appointment, her contribution towards making Göttingen University an important centre of mathematical research and teaching was significant.

Noether was an effective but not easy-to-follow teacher. But those who could follow her style of teaching came up with original ideas. She cared about her students and she was always ready to listen their problems. In fact she considered her students as members of her family. She loved to discuss with her students. "A keen mind and infectious enthusiasm for mathematical research made Emmy Noether an effective teacher, although she could not be described as good teacher. Her classroom technique, like her thinking, was strongly conceptual. Rather than simply lecturing, she conducted discussion sessions in which she would



David Hilbert



Hermann Weyl

explore some topic with her students. She loved to spend free time with them, especially on long walks. Sometimes she would become so engrossed in the conversation that her students would have to remind her to watch for traffic. On one memorable occasion her slip came down when she was lecturing – she bent down, pulled it off, threw it in the corridor, and kept on lecturing.” She taught his students to teach themselves. Many of her students made notable contributions to mathematics.



Hermann Minkowski

She was invited to give a lecture at the 1928 International Mathematical Congress in Bologna. She also gave courses at the University of Moscow in the winter of 1928/9. In recognition of the importance of her work the International Mathematical Congress in Zurich asked her to give a plenary lecture in 1932. She was also awarded the prestigious Ackermann-Teubner Memorial Prize in mathematics. On her 50th Birthday her extended group of algebraists organised a celebration in her honour.

When the Nazis came to power in 1933, Noether, like many others of Jewish origin, had to leave the German universities. Like all other Jewish people it became dangerous for her to stay in Germany. She moved to USA. She was offered a visiting professorship at Bryn Mawr College. It was



Christian Felix Klein

a women’s undergraduate college. This was for her the first normal faculty appointment. She also gave lectures at the Institute for Advanced Study in Princeton. She enjoyed her work at Bryn Mawr College. However, it was not to be a long innings. She could work only for two years before her sudden death on 14 April 1935. She died at the age of 53.

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(This article is a popular compilation of the important points on life and work of Emmy Noether available in the existing literature. The idea is to inspire the younger generation to know more about Noether and her work. The author has given the sources consulted for writing the 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)

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In Search Of Pleasure – From Caffeine...

How wide spread is drug abuse in India? According to a study conducted by the United Nations Office on Drugs and Crime and the Ministry of Social Justice in 2004, there were 8.75 million users of cannabis, 2.04 million users of opiates such as heroin, and 0.29 million users of sedatives. According to media reports, India has become a transit route for drug traffickers, who smuggle heroin from the opium producing areas of Afghanistan and Myanmar, to other parts of the world. Indeed, the culture has enormously changed in the last couple of decades.

But, why do our youth fall prey to drugs anyway? The reasons could be numerous and may vary from one group to another. According to some psychologists, the rich and the famous have all the materialistic pleasures, and therefore there is certain vacuum in their lives. They need something more to excite them, and the drugs provide the easy answer. For them cocaine is the drug of choice, being costliest in the market. Then there are youngsters who get into drugs to escape from reality. To them drugs provide a false sense of being in control and temporary state of euphoria. Gradually they become habitual drug abusers and develop a craving for it.

However, drug abuse could turn fatal when an abuser overshoots his capacity or when these substances are mixed with medication, alcohol or other drugs. Everybody has a capacity for drug intake, but when they go beyond the tolerance level of their bodies, it could prove fatal. What does the law say in this regard? If one is caught even with one gram of drugs for personal consumption, the punishment varies from imprisonment of six months to one year, or a substantial fine. However, if one is caught with larger possession of drugs, or selling or marketing the same, one may be imprisoned for ten years or more or fined heavily. Certainly we need stricter laws, and stricter enforcement of these laws to counter the invasion of drugs amongst our youth.

We have come a long way since the days of *sura* and *aphena*; and from caffeine to cocaine. What is the solution then? There is no gainsaying the fact that there is plenty of awareness on the dangers of smoking, but very little on drug abuse. Merely terming drug abuse as illegal cannot solve the problem. It would only make the youth more curious to try it out. What is required is a concerted campaign on awareness and the dangers of drug abuse especially amongst the youth. Equally important is the rehabilitation of those who have already fallen victim to it. They need care and they need help. This needs to be a part of our science awareness campaigns.

□ **V. B. Kamble**

Parity – Nature's Broken Mirror

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One of basic tenets of all scientific discoveries is that all the laws of nature and therefore the results of experiments must be reproducible and remain invariable under time and space translation, space rotation, etc., and these invariances lead to different conservation principles. For example, invariability under time and space translations implies respectively the conservation of energy and the momentum, while that under space rotation leads to the conservation of angular momentum. Thus the search for the invariance principles is the most fundamental and forms a solid foundation for any physical theory in process of development. Until the middle of 20th century, there were no known laws of nature that could provide an operational definition of left and right.

Until 1957, all human experiences had buttressed the idea that there is no intrinsic distinction between the physical phenomenon found in the real world and its mirror image; no natural process or law of nature can point out the asymmetry between right and left if it exists. Accordingly, there can be no absolute distinction between a real object and its mirror image. Your left and right hands are simply counterparts though they look different. Look at your right hand in a mirror; you'll see it as your left hand. The same is true of your left hand; it would appear in the mirror as your right hand. Conventionally we assume right automatically becomes left in a mirror.

In the high school science course, you have the famous right-hand-rule for telling the direction of an electromagnetic field (grasp the wire carrying current with your right hand, so that the thumb points to the direction of the current flow, then your finger tips point to the direction of the magnetic field around the wire). You might say that the North Pole is the one that points towards north of the Earth; but who made this rule? It is not a rule of nature; it is merely a convention. We can even reverse it without any difficulty. In that case it will be left-hand-rule. All our right-hand-rules are purely conventions. There is nothing in the electromagnetic field that permits an absolute distinction between an event and its mirror image.

In an analogous way, the indistinguishability of magnetic north and south poles implies one of the mirror invariance. These are conventionally different. Physicists had long known that mirror symmetry prevails in the macro world. Mirror symmetry allowed the physicists to calculate many quantities that seemed virtually incalculable before, by invoking the "mirror" description of a given physical situation, which can be often much easier. But now we know that the mirror symmetry that extends down to atomic and sub-atomic level.

The preceding concept of mirror symmetry (or left and right symmetry) does not mean that asymmetry is not

present in the universe. For example, human beings have their hearts slightly to the left side of their chest. This is not nature's left-handedness; it is merely accident in the evolution of life on our planet. Theoretically, one can construct human beings with their hearts on right side. In fact, there are some persons who have their hearts slightly to the right hand side. Although, the number of persons having their hearts on the right hand side is extremely rare, our law of mirror symmetry does not say that the mirror image of the asymmetric structure must exist in equal numbers. It only says that there is nothing in nature's laws that prohibits the existence of both types of handedness. Actually on our planet, there are a large number of asymmetric systems in the living world, but the existence of their counterparts is equally probable.

A few such systems are: shells of mollusks or snail which have right-handed conical helices; but there are others which have left-handed helices. It is quite possible that these may well be compensated for by the existence of other living beings on some other planet orbiting some other sun of other galaxies whose structures are the mirror images of ours. The asymmetries in the living and non-living systems on our planet is merely a matter of chance in the evolutionary process.

The concept of spatial and non-spatial symmetries and asymmetries is an important principle in the micro world of particles that permit us to give an orderly and systematic account of certain phenomena in the universe. These lead to a number of conservation principles, of which the one that implies the fundamental never changing mirror symmetry of the universe and that lacks the bias for left and right in the basic laws of nature is the law of the "conservation of parity".

The concept of parity is an old one. If one takes two integers and if both of them are odd like 23 and 37, or if both are even like 32 and 44, then the mathematician would say, they have the same parity; but if one integer is odd and the other even, like 27 and 18, they call them as having opposite parity. Since every even integer is of the form $2k$ and every odd integer is of the form $2k' + 1$, it can be proved that the two integers having the same parity follow the following axiom:

$$(2k \pm 2k') = 2(k \pm k') \text{ and} \\ (2k + 1) \pm (2k' + 1) = 2(k \pm k') + 2 \quad (1)$$

In the case of opposite parities, one has

$$(2k + 1) \pm 2k' = 2(k \pm k') + 1$$

This can be explained by the following examples:

Game I: Take three one-rupee coins. Place them on a table with the heads of all three up. Turn the coins over one

Table 1 : Even and Odd Parity

No.	Positions of Heads of three coins starting with three Heads (H) up after even number of turns with start HHH	Position of Heads of three coins starting with three Heads (H) up after odd number of turns with start HHH	Change of Parity
1	T T H	H H T	Parity changes of any pattern in column 2 or 3 is given old number of turns patterns in column 2 changes pattern column 3 ↔
2	H T T	T H H	
3	T H T	H T H	
4	H H H	T T T	
	Even parity patterns	Odd parity patterns	

direction of arrow so that a_2 goes to a_3 , $a_5 \rightarrow a_4$ etc. These points after reflection go to a'_1, a'_2 a'_6 (which are also rotating in the same direction as $a_1 a_2 a_3$ a_6). Though the octahedron has been turned upside down after reflection, the two octahedra (original and reflected) are superposable. In short, the whole system remains unchanged by the change of sign of Z-coordinates.

at a time, taking them in any order. Turn one coin, then another and so on. Count the number of turns. If you make an even number of turns, for example, 10, 24, 30, etc., you will find no matter what the number, only one of the combinations given in column 2 of Table 1 will appear. Name them as even systems.

Similarly, again place the three coins with their heads up and make an odd number of turns, say, 11, 13, 21, 23, etc., one at a time taking the coins in any order. This time you will end up with one of the patterns given in column 3 of Table 1. Call them as odd systems.

The set of patterns given in column 2 is said to have "Even" parity while the ones given in column 3 is said to have "Odd" parity. Further turning of the coins will show that any number of turns will give you one of the patterns given in column 2 or 3, depending upon whether the number is even or odd. It implies that (i) the parity of a pattern is conserved by the evenness or oddness of the number of turns, and (ii) any pattern-change changes its parity.

Game II: We start this time with a large number of coins; say 20, with all their heads up. You count the number of coins (in this case 20). Now you turn your back and ask your friend to turn the coins. He turns them at random, but each time he turns, he shouts "Turned". Keep note of the number of times he shouted, "Turned". Suddenly he stops and covers one coin with his hand asks you "What is it, head or tail?" You turn around and count the number of coins with heads up.

If the number of times your friend had shouted, "Turned" is even, e.g., 20, then the parity of the pattern will not change, i.e., the number of remaining heads will be an even number. In this way you can guess the top of the hidden coin (head or tail).

The method given above is called the "Parity check". Configuration of pieces on the field after some play has been mathematically analyzed using parity principles.

Let us apply this criterion of defunct parity to a rotating system. Let us take an octahedron (shown in Fig.1) rotating along the t-axis in the clockwise direction. Let us reflect it in the X-Y plane. The reflected octahedron is also shown in the Fig.1. In the reflected image the Z coordinates of all the points at any one particular time will be changed to $-Z$. Note the other octahedron rotates in the

Now let us take the case of an unsymmetrical rotating tetrahedron. It is also reflected in the X-Y plane as shown in the Fig. 2, in which Z-coordinates of all the points of the tetrahedron are changed to $-Z$. Are the two tetrahedrons superposable? Whatever you do,

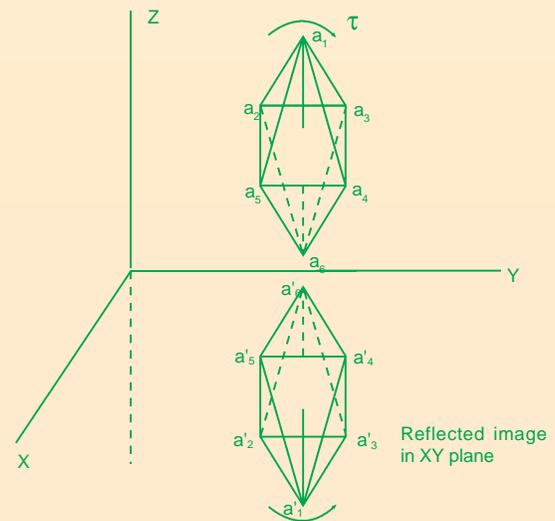


Fig 1 : Reflection of an octahedron in XY plane

these two tetrahedrons cannot be superposed on each other. It implies that the unsymmetrical tetrahedron possesses 'handedness'.

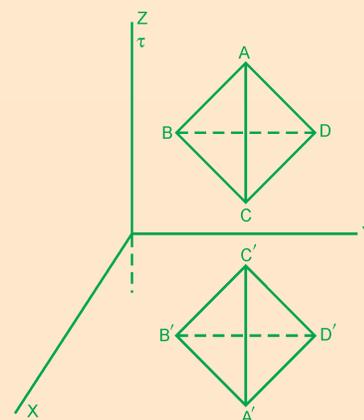


Fig 2 : Reflection of an irregular tetrahedron XY plane

Compare the preceding two systems – one with the octahedron having a plane of symmetry ($a_2 a_3 a_4 a_5$), and the other with an irregular tetrahedron with no symmetry. The octahedron remains unchanged on reflection. But the tetrahedron becomes non-superposable on reflection and such systems are said to have odd (or indefinite) parity. Drawing a parallelism with the example of the three one-rupee coins with their heads up discussed earlier, the octahedron, with the three coordinates of all the points (viz., x, y, z) either all plus or all minus, behaves in a manner analogous to three coins each of which can have head or tail ends up. If the system is asymmetrical (tetrahedron case) any odd number of sign changes (here one sign change is the change in two coordinates for obtaining the reflected mirror image) has the same effect as that of three coins with their heads up with one turn (odd number), i.e., the parity is changed to odd.

We can do three operations in the case of the tetrahedron, viz., three reflections at the origin of the coordinate system. These three operations will imply changing the signs of all the three coordinates ($x, y, z \rightarrow -x, -y, -z$). Again, an odd number of reflection operations changes the parity to odd if we take the original parity as even. If you reflect the once reflected image (two reflections in the same or in different planes at right angles to each other), you will obtain the original figure. Thus, every even-numbered reflected image of a tetrahedron will be the same as the original tetrahedron, which would imply that the parity of the tetrahedron is not changed. Thus, the number of times the signs of the coordinates (x, y, z) of any system is changed is equivalent to the number of times the coins were turned. This number can be even or odd. Even number brings the original figure back (i.e., parity not changed), because for even \times even \times n -times, if $n = \text{even}$ or odd, the system will be even, i.e., parity of the system will not be changed. But for odd \times odd \times n times ($n = 1, 2, \dots$), if $n = \text{odd}$, the parity will change. So an even number of reflections imply that the left will go to left and right will go to right, but an odd number of reflections of a system will change the system from left to right and from right to left. Thus the parity is also connected with the left- and right-handedness of the system. In other words, an odd number of reflections change the handedness of a system, but an even number of reflections does not.

There are two sets of coordinate systems – Right-handed (RH) and Left-handed (LH) (see Fig. 3). In order to define our laws of nature, we choose one of the systems. Conventionally we choose the RH system. These laws define the various processes of nature. Now the question is: "Would our laws of nature and the description of process of what does or does not happen in nature be different if we choose the LH coordinate system instead?" Or will the laws of science take the same form in the LH system as they are in the RH system? If any one of the laws does have a different form, then we would

have identified a law that would distinguish left from right. We must develop a theoretical method by which we can tell if a particular law takes different forms in RH and LH coordinate systems.

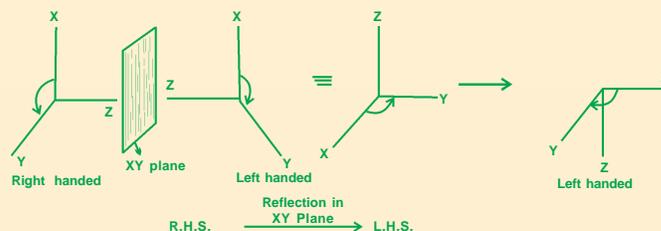


Fig 3 : Left and Righthanded coordinate system

Theory of relativity deals with four types of coordinate transformations. These are: (a) Translation of origin of the coordinate system in space; (b) translation of the set of axes in space; (c) translation of origin in space-time coordinate system; (d) moving the origin of the coordinate system with uniform velocity.

In all the above transformations, the common characteristic is that square of the distance between the two points in space-time, $(S_{AB})^2$, remains constant. All laws involving $(S_{AB})^2$ remain invariant under these transformations. Beside these transformations there are two other transformations that leave $(S_{AB})^2$ invariant. These are: (i) Space inversion (parity transformation) in which all space-time changes according to $t' = t$ and $(x', y', z') = (-x, -y, -z)$; and (ii) Time reversal (T) in which one re-labels all space-time events according to $(x', y', z') = (+x, +y, +z)$ and $t' = -t$. The latter two transformations change our coordinate system from RH to LH. But they do not bring any change in our space-time.

It can be seen that space inversion changes the signs of all displacement vectors. This is exactly what happens when we reverse all the three axes (see Fig. 4). It implies that space inversion (parity change) is equivalent to two transformations.

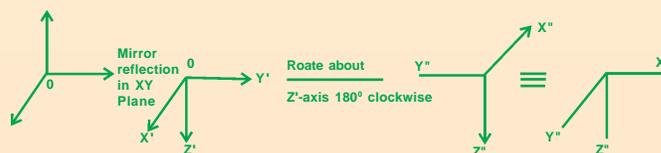


Fig 4 : Two transformations are equivalent to space-Inversion transformations

In the scientific world, parity is a mathematical concept, which is difficult to define. In scientific terms, it is a property of the so-called wave function by which quantum mechanics describes the characteristic of a particle and represents its position in space. These wave functions are function of (x, y, z) coordinates. But the wave function can characterize the probability of the position, momentum or angular momentum, etc., of the particle. The wave function can be only of even or odd parity to which we assign quantum numbers $+1$ and -1 respectively. The applications of

these particles or quantum numbers are not limited to quantum mechanical wave functions only but can also be applied to all other types of mathematical functions of x , y , z coordinates as variables.

Physicists found it useful to apply the concept of parity to the wave functions that describe elementary or subatomic particles. Any particles can be described by a wave function with x , y , z as space coordinates. To them one can also assign a quantum number $+1$ or -1 depending upon the nature of its transformation under space inversion. It has been proved that normally in any isolated process of particle interactions, parity of the system is usually conserved. For example, if a particle of even parity (quantum number $+1$) is transformed into two particles in any process then both the newly formed particles must either be of even parity or of odd parity, such that two parities together ($\text{even} \times \text{even} = \text{odd} \times \text{odd} = \text{even}$) should be of even parity. The parity is conserved in the interaction. However, if one of the newly formed particles is of even parity and the other of odd parity, then the overall parity of the two newly formed particles will be odd and parity will not be conserved in the interaction. In 1927, Eugene P. Wigner showed that the conservation of parities in nature rests upon the fact that all forces involved in particle-particle interactions do not have left-right bias. Any departure in this law is equivalent to a violation of mirror symmetry in the basic laws governing the interactions of particles. The conservation of parity suggests that mirror symmetry filters down to the atomic and subatomic particles.

Scientists were discovering new particles one after another with a conviction that the parity is always conserved in all the interactions (electromagnetic, strong, weak, gravitational). Dirac's hole theory of particles predicted the existence of antiparticles, which was accepted with difficulty by the contemporary experimental physicists, and Anderson's positron was the first experimental antiparticle (anti-electron) discovered. Similarly, antineutron was discovered. By 1956, physicists had found the antiparticles of nearly all the existing particles except those of photon and neutral π -meson. They anticipated the presence of anti-atom, anti-molecule and above all, antimatter, anti-galaxies, etc. In all these experimental processes, they did not find the violation of parity conservation law. In every process, the labelling of opposite properties e.g., $+ve$ and $-ve$, N and S poles, etc., describes a state of affairs that does not involve a violation of right and left symmetry. One can draw pictures of particles and antiparticles in such a way that each appears as mirror image of each other (Fig. 5).

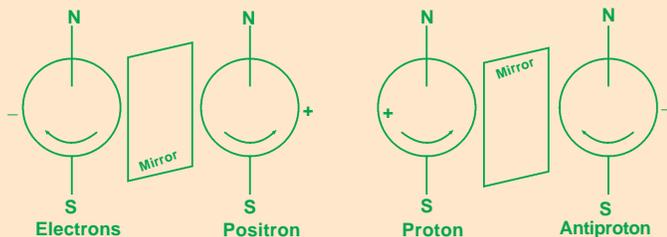
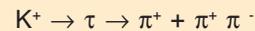
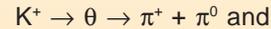


Fig 5 : Mirror images of electron/positron and proton/anti-proton

Although particles and antiparticles are shown as diagrams in the figure, these can be expressed accurately by their respective wave functions. To them one can assign a definite parity ($+1$, or -1). The only difference in the particle and its antiparticle, apart from their mirror images, is that one has a positive charge while the other is its negative analogue. Could it be that this distinction between $+ve$ and $-ve$ charge (thus their bias for left/right) may rest on some unknown asymmetric structure inside the particle itself? This will be seen only in the future. If there is a spatial asymmetry of any kind, it should show itself in the violation of the parity law. No such violation was observed until 1956. Prior to that time, the law of parity was believed to be infallible in all the four types of fundamental interactions (see above) responsible for all events occurring in the universe.

In 1956, physicists were scratching their heads over the "Theta-Tau" puzzle, which arose in connection with one of the weak interactions involving a "strange particle" called K-meson. The K-meson decays into θ and τ particles are as under:



The lifetime and the masses of both these particles (θ and τ) are the same.

Normally, when one finds a common mass and a common half-life associated with the decay processes, one concludes that the two particles are the same and that they are decaying by two different routes. For example, in the processes $\tau = \pi^+ + \pi^+ \pi^-$ and $\theta = \pi^+ + \pi^0$, θ and τ should be the same particle. But if we consider the law of conservation of parity in these processes, π is known to have odd parity. This implies that τ particles should be of even parity ($\text{odd} \times \text{odd} = \text{even}$).

Thus the puzzle:

- If θ and τ are different, then why are the masses and half-lives of θ and τ the same?
- If θ and τ are same, then why is parity not conserved in the two processes?

Tsung-Dao Lee and Chen Ning Yang proposed very bravely that during *weak interaction* parity is NOT conserved. In order to prove their hypothesis, they proposed an experiment to determine if the weak interactions differentiate between right and left. One such suggested experiment was the decay of ^{60}Co ($^{60}\text{Co} \rightarrow ^{60}\text{Ni} + e + \nu_n$), which was thought to decay by weak interaction. ^{60}Co is thought of as a tiny sphere spinning like a top on an axis labelled N- and S-pole and that electrons (β particles) are emitted by the ^{60}Co nuclei along the two poles. Lee and Yang calculated the velocities of electrons coming out from both N- and S-pole ends of the nuclei. Normally, a spinning nucleus should point in all the directions, and so the electrons should also come out in all directions at normal temperature. But if ^{60}Co is cooled to near-absolute zero (-273°C) to reduce all the thermal wobbling, the ^{60}Co nuclei would line up with their N-poles along the magnetic field. This should make the elec-

trons coming out in two directions only, viz., the N- and S- ends. In case parity is conserved, one would expect that there would be just as many electrons going in one way as in the other. But if the decay processes showed a left/right bias and parity is not conserved, more electrons would be emitted in one direction than in the other. The above experiment was carried out by Chien-Shiung Wu in 1956. In her experiment, the numbers of electrons emitted in the two directions were not equal. Most electrons were emitted from the S-end.

Let us see how this experiment is so revolutionary. Fig. 6 shows a picture of ^{60}Co nucleus spinning in a certain direction around N-S axis. Wu's experimental results provided us for the first time a method of labeling the ends of a magnetic axis that is not a mere convention. We can say now that the 'south' end is the end of a ^{60}Co nucleus from which most of the electrons come out during β -decay. Thus in weak interactions, nature shows by its own intrinsic handedness in the form of μ and π mesons, which also decay by weak interactions. In both cases the law of parity conservation is violated. By the end of 1958, it was more or less definitely concluded that parity is violated in weak interactions.

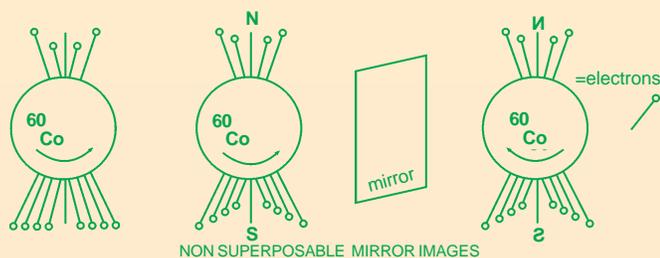


Fig 6 : Reflection of ^{60}Co nucleus

Nature has given us another surprise. Though it is surprising that certain particles like ^{60}Co showed handedness, it is more surprising to know that this handedness is limited only to weak interactions. Lee and Yang were awarded the Nobel Prize in 1957 for this discovery. To add to this surprise, J. Cronin and his team in 1964 showed that in the decay of the particles called neutral kaons, not only is the spatial symmetry (P) violated but also the symmetry between particles and antiparticles (C) was violated. Thus weak interactions show very astonishing properties, and violation of both P and CP symmetries has been observed only in weak interactions.

Neutral K mesons are generally produced in collisions between a proton beam and a stationary metal target. In millions of collisions the short-lived variety of K-meson always breaks into two π mesons while the long-lived variety occasionally shows a hump in the data. It was shown by J. Cronin that two different particles did not decay into the same products. Cronin was awarded the Noble Prize (1980) for this work.

Nature has forced the scientists to think that the great invariance principles of Nature should be relied upon within the domains of their applications. It has been very beautifully expressed in the great religious symbol of the orient "Yin-



Fig 7 : Asymmetric Yin Yang Symbol of Orient

Yang" (Fig. 7). It is a circle which has been divided asymmetrically. The dark and the light areas are respectively known as the Yin and the Yang, representing duality of life, e.g., good and evil, odd and even, left and right, etc. The dots remind us that nothing is "perfect", but the search for near-perfectness must go on!

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Posture and Poise



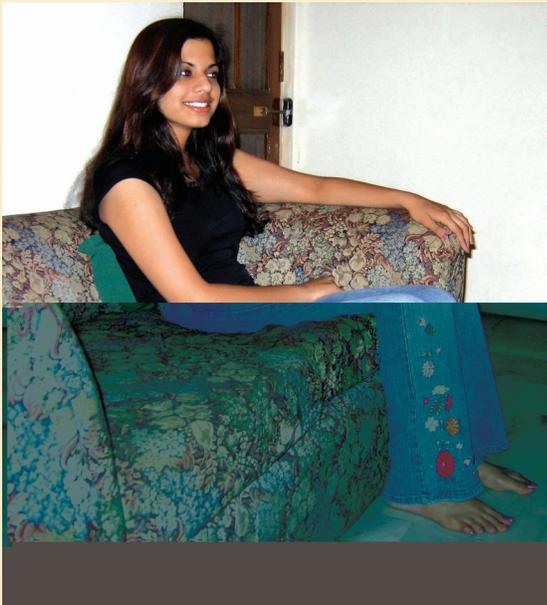
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The way you sit, stand and walk, work on the desk, lift and carry objects, choose footwear, travel, sleep, maintain your body weight, and the positive energy you exude has a telling effect on the health of your back. If you wish to reduce the wear and tear of the muscles, bones and joints of your back, make it a habit to keep a good posture. It also adds considerably to your poise.

Sit correctly

Sitting puts a lot of strain on the lower back. There is a 50 per cent higher compression on the lower back discs than if you were standing. Think about your daily routine – whether it is reading, working at a desk, watching televi-



Correct posture of sitting

sion, travelling, or eating, and you'll probably find that you spend most part of your waking hours in a seated position. Despite this, few of us pay sufficient attention to how we sit. The basics are simple – sitting correctly simply means that:

- Your feet are supported on the floor.
- Your knees are bent at a 90-degree angle.
- Your hips are at the same height or slightly higher than your knees.
- Your back is fully supported – especially in the hollow curve.
- You sit far back into your seat.
- Your head and shoulders are in line with your hips.
- Your abdominal stabilizers are contracted.

Relaxing at home

The seeds of posture-related back pain are often sown as people sit at home, relaxing from the stress engendered by a hard day at work. Sometimes we are plain too lazy to care about posture, but the problem may also relate to ill designed couches or chairs.

Use back-friendly sofas and chairs

Furniture designers should all receive a basic lesson about the needs of the human back. The spine's natural curve needs support in the lower back and much home furniture does not provide this.

Sofas and easy chairs can cause back problems if they are too soft, the seat is too low and too deep, or the backrest is too short. An overly deep seat forces you to either sit forward with your feet on the floor, a position that encourages you to hunch, or with your lumbar region against the backrest and your feet off the floor. Both these positions may bring on back pain. If the seat is too soft or excessively low, then also you could be in trouble. You are likely to sit in a position that puts excess strain on your spine.

A back-friendly easy chair allows you to sit with your lower back firmly against the backrest and both feet flat on the floor. The backrest should also be shaped to give some extra support to the lumbar region. If it is not, place a cushion or two behind the small of your back. If the seat is too low, you maybe able to have new, higher legs fitted by your carpenter.

Watch your posture

Even the best designed sofas and armchairs may not protect your back if you do not pay attention to your posture. Sit upright, make sure the small of your back is supported and keep your feet on the floor. Do not slide into a lounging position. Many people do, but that's not correct. By sliding down the chair you cause an excessive rounding of your back, and this position subjects your back to additional strain.

Watching television or reading

While watching television, it's best to sit in a chair positioned in front of the screen. This way you do not have to crane your neck to see the picture.

Many people, however, like to lie in bed, or on their side with their head on the armrest of the sofa while reading, watching television or dozing. It's a habit you could do well without. The angle of the armrest strains the neck, leading to neck pain. If you must take this position, try to keep

your neck in the neutral position by sitting up a bit. Support your neck with cushions and try to move every 30 minutes to even the strain.

The position of the television is also important. It should ideally be placed at your eye level. This way you will be able to keep your head in the neutral position while watching. A television kept too high or too low puts strain on the neck.

Take a break

Whatever you do, take a break every now and then. Change your position. Stand up and move around. Stretch your back. It does your back a world of good.

Stand and walk correctly

It is important that you allow your spine to retain its natural shape by standing and walking correctly. Keep your posture as upright as possible. As you stand and walk, make an effort to straighten up.

Keep your stomach in, your back straight and try not to hunch your shoulders. But do not overdo it. Do not try to march around with your upper body rigid like a *sipahi* on parade, as this can also cause strained and painful muscles.

If you must stand for a long while, stand with one foot firmly planted on the ground, and rest the other on a ledge, stone or railing. A footstool is extremely useful. Rest your back against the wall. Use a handrail. Change legs every few minutes.

Workplace etiquette

If your job makes you feel like a hunchback, you need help. Follow these simple guidelines:

Find a comfortable position : Use a chair that supports your lower back's curve or place a rolled towel or pillow behind your lower back. The seat of your chair should not press on the back of your thighs or knees. If you can afford to procure a new chair, find one with the attributes described here.

Relax : Check your shoulders from time to time. Are they tense? Take three deep breaths. Make a conscious effort to relax them.

Change positions often : Get up and move. For example, stand while you're on the phone. Print out computer files, move to a new location and proofread on paper instead of the monitor.

Avoid high-risk moves : Don't bend continuously over your work. Hold reading materials at eye level. If you are on the phone a lot, get a headset. Too much twisting, bending and reaching fatigue your back and leave it vulnerable to injury.

Rest your feet : If you stand for long periods, rest one foot on a footrest or stool from time to time. Change leg positions often.

Lift objects properly : Carry objects close to the body at about waist level.

Working on a computer

Computers are increasingly becoming a part of life in each and every vocation. If you work long hours at a computer, here's what you must be careful about:

- Keep your computer monitor and your keyboard at a proper height. The computer screen should be positioned straight in front of you. It should be 15 degrees lower than the height of your eyes and about an arm's length away from you. In the seated position, your work surface should ideally be at elbow height. So should your keyboard. Lighting should be adequate and the screen should be in focus.



Simple stretching exercise can help prevent strain on the neck back

- Sit comfortably upright. Use a proper work chair. Avoid slouching.
- If you do a lot of word processing, you should consider getting a stand to hold documents. Placed adjacent and at the same height to the screen, the stand will limit straining. You will not need to look up and down repeatedly.
- Use a good wrist pad and armrests.
- If you have problems with your eyes, consider getting a bigger screen so that you can see more clearly without having to poke your chin forward.
- Make sure your eyeglasses allow you to see the screen without tilting your head. If you use bifocal lenses, avoid wearing them while working at a computer. If you do, you will tilt your head back to look through the bottom of your glasses, and this shall strain your neck.
- Often we tend to sit in front of the computer for long periods of time, forgetting about posture and not checking whether we are actually comfortable. This can damage your back. Take 30-second micro-breaks every 30 minutes. During these breaks move your neck from side to side and turn your back from left to right; this will help prevent strain on the neck back.
- Don't type while cradling the phone on your shoulder. Use a speakerphone. If you spend much time

on the phone, consider using a headset.

Finding a good worktable and chair

Never hesitate in investing in a back-friendly worktable and chair – it's a must for maintenance of good posture. You may decide by looking for the following virtues:

Worktable

- The table should be of suitable height such as you do not suffer strain on the back while working. If it is too low, you might stoop during work.
- A desktop that has a slant or tilting top is ideal for reading and writing.
- It should also allow leg space under it, to prevent undue arching forward of the back and the neck.

Desk chair

- Sit in a desk chair that supports your upper spine and your lower back and keeps your knees and hips level. Ideally, you should be able to adjust its height to suit your height as well as the level of your desk.
- It must be able to swivel, so that your body does not have to turn from left to right all the time.
- It must support the hollow part of your lower back.
- It must have armrests that are as high as your elbows, when your arms are bent at 90 degrees. A chair with arm supports helps relieve neck tension.
- It must be the right height for the surface at which you are sitting, thereby minimizing the amount of time you will have to bend down or lift your arms excessively to do your work.
- It must have a soft but firm cushion.

Footwear selection

Your shoes also influence your posture. They could be the culprits behind back pain. Look for the following qualities when you next shop for a new pair:

Wear low-heeled shoes : Stiletto-type heels are the worst, but all high-heeled shoes may cause problems. They hollow the lower back, push the whole body out of alignment and strain the leg muscles.

Well-cushioned, comfortable walking shoes with a heel of not more than 2.5 cm (1 in) are the most back-friendly footwear. For smarter shoes, choose a pair with heels that are less than 5 cm (2 in) high and try not to stand for long periods. Kick them off soon as you are home.

Tie your laces : If you wear shoes with laces, tie them up properly. Wearing them unlaced causes you to curl your toes in order to grip the soles, transmitting tension through your legs and into your back.

Lifting and carrying

Your back has three natural curves – inward at your neck, outward at your shoulder blades and inward again at the small of your back. Whether you're carrying a heavy

shopping bag, lugging a suitcase or toting your toddler, you must preserve the proper alignment of these curves to prevent back injury.

Think through your task : Clear the space for proper lifting. Make sure the pathway and your destination are clear of obstacles. Would the task be easier if you used a cart? When possible, push a heavy load rather than pull.



Cradling the phone on your shoulder can cause neck pain

Lift with your legs : Position your feet shoulder-width apart. Place your feet firmly – toes pointed slightly outward, one foot slightly ahead of the other. Stand as close to the load as possible.

Never stoop to pick the load from the ground. Instead, bend from your knees, and use your powerful leg muscles to lift the load. Keep your back as upright as possible. Hug the load. As you lift, tighten the abdominal muscles that support your spine.

While holding the load, avoid turning or twisting. Carry the load close to your body. This way it puts less force on your lower back.

Travel and your back

Driving in a car: If you live in a big city, you could be spending considerable amount of time in the car, either driving to and back from work or on social and domestic visits. To protect your back, here's what you must do:

Sit up : Try to sit upright with your chin tucked in rather than stuck out.

Do not slouch : Do not grip the wheel too tightly, try not to hunch your shoulders and keep your head up. After driving for a few minutes, most people find they unconsciously slump down a bit. Keep a check on this.

Adjust your seat : Your seat should be firm and offer support for the lumbar region of the back. It should be adjusted to allow you to sit upright with your arms relaxed.

Your legs should be comfortable, and you should be able to depress the clutch pedal or accelerator with ease. If the seat does not provide adequate lumbar support, use a cushion.

Adjust the headrest : Adjust the headrest fitted to your car seat, such that it supports your head in the event of a sudden stop that could abruptly jerk your neck backward and forward.

Stop and stretch : A long car journey can be stressful for the back. Even in a car with the best suspension, a continuous series of minor shocks and stresses are transmitted up the spine. Therefore, the next time you embark on a trans-city journey by car, try to build in time for at least two-hourly stops to get out and move around. Step out and stretch yourself. This will ease the strain on the back and hamstrings.

Road and train travel

Travelling in buses and trains is rather stressful for the back. You must remain seated in the same posture for considerable periods of time. There's however one recipe to ease your back. If you are a bus passenger, make sure you get out and stretch your legs at every available rest stop. On trains, move out of your seat every 30 or 40 minutes to exercise your back by strolling up and down the passageway.

Travelling by air

Air travel holds many risks for those with back problems, beginning right at the start of the journey. The seats in airport lounges usually have low backrests and little, if any, lumbar support. If you have a long wait, use a rolled-up towel, sweater or coat to give you some lumbar support. Get up every 30 minutes and do some simple muscle stretching or go for a walk.

The standard seats on most aircraft are not usually particularly comfortable and the rows are often so close together that there is not much legroom. However, a cushion placed at the small of your back will give you some extra lumbar support. Most airlines provide a cushion. If not, a folded blanket works equally well.

Lugging baggage

Some people travel real light and manage to do just with a shoulder bag. But there are rules for even that. Change it regularly from shoulder to shoulder to equalize the strain on your spine and upper back. Heavy shoulder bags carried for any length of time on one side of the body or with the strap around the neck can strain the back. It is far better to try and divide a heavy load between two handbags.

If you have to take a single large suitcase, buy one with stable wheels or use a folding luggage trolley to lug it around. Fortunately, most airports in this part of the world let you use a cart, which are lined right next to the point of entry and the baggage claim. Still, there are areas over which you have to carry the bag, for example up and

down stairs. Make sure, too, that the case is not so tall that you have to bend your arms to keep the bottom from bumping on the ground. This can strain the back. Carrying a single, heavy suitcase for any length of time is almost guaranteed to cause back trouble. Equalize the load on your spine by dividing your luggage. Take two small cases.

Beds and backs

People spend up to a third of their lives in bed and yet, often do not care about how good their sleeping apparatus is. If your bed is sagging, worn out or uneven, and you wake up feeling stiff and sore, you have only yourself to blame. A bed, which allows the spine to sag, strains the muscles and ligaments of the back. If that's the case, you should consider buying a new one.

The proper bed

The ideal bed should be both supportive and comfortable. It should be firm enough to support your back, and at the same time soft enough to mould to the contours of your body and support its hollows and curves. A bed with a wooden board as its top, covered with a good 5-8 cm-thick mattress, which is soft but firm and does not have any holes or indentations, makes a perfect bed.

The best sleeping position

Sleeping on your side: The best sleeping position for your lower back is to sleep on your side. Let your legs be drawn up slightly toward your chest and place a pillow between the legs. By sleeping in this neutral position, you do not risk stretching your vertebral column.

Sleeping on your back: Lying on your back is not a bad second option. If you experience discomfort in your lower back in this position, place a pillow under your knees. It will help ease the strain caused by the pull of the hip flexors and hamstrings.

Sleeping on your stomach: This is a far from ideal position, but if it's your favourite, it is advisable to place a pillow underneath your stomach. This will prevent excessive hollowing. The prone position does put some strain on your neck because it is forced to turn to the side. If you like sleeping on your stomach, try and turn slightly so that you are half on your stomach and half on your side.

Pillow talk

Your head pillow should be just the right height to keep the neck in the neutral position and not bend it forward or backwards. It is important to make sure that your shoulders are not on your pillow as it is only your neck and head that will benefit from support. You will need more height in your pillows when you sleep on your side than when you sleep on your back.

A pillow that can mould around your neck usually works well. For example, a soft pillow made of feather. A physiotherapist can guide you on how to design pillows best suited to your neck.

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Earthquake Tip 3

What are Magnitude and Intensity?

Terminology

The point on the fault where slip starts is the *focus* or *hypocenter*, and the point vertically above this on the surface of the Earth is the *epicenter* (Figure 1). The depth of focus from the epicenter, called *focal depth*, is an important parameter in determining the damaging potential of an earthquake. Most of the damaging earthquakes have shallow focus with focal depths less than about 70km. Distance from epicenter to any point of interest is called *epicentral distance*.

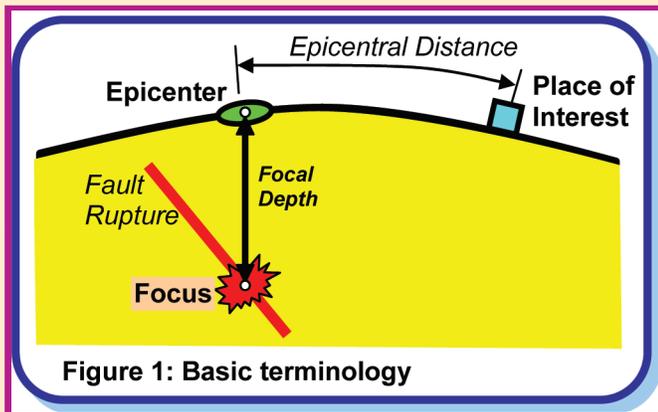


Figure 1: Basic terminology

A number of smaller size earthquakes take place before and after a big earthquake (*i.e.*, the *main shock*). Those occurring before the big one are called *foreshocks*, and the ones after are called *aftershocks*.

Magnitude

Magnitude is a *quantitative* measure of the actual size of the earthquake. Professor Charles Richter noticed that (a) at the same distance, seismograms (records of earthquake ground vibration) of larger earthquakes have bigger wave amplitude than those of smaller earthquakes; and (b) for a given earthquake, seismograms at farther distances have smaller wave amplitude than those at close distances. These prompted him to propose the now commonly used magnitude scale, the *Richter scale*. It is obtained from the seismograms and accounts for the dependence of waveform amplitude on epicentral distance. This scale is also called *local magnitude scale*. There are other magnitude scales, like the *body wave magnitude*, *surface wave magnitude* and *wave energy magnitude*. These *numerical* magnitude scales have no upper and lower limits; the magnitude of a very small earthquake can be zero or even negative.

An increase in magnitude (M) by 1.0 implies 10 times higher waveform amplitude and about 31 times higher energy released. For instance, energy released in a $M7.7$ earthquake is about 31 times that released in a $M6.7$ earthquake, and is about 1,000 ($\sim 31 \times 31$) times that released in a $M5.7$ earthquake. Most of the energy released goes into heat and fracturing the rocks, and only a small fraction of it (fortunately) goes into

the seismic waves that travel to large distances causing shaking of the ground en-route and hence damage to structures. (*Did you know?* The energy released by a $M6.3$ earthquake is equivalent to that released by the 1945 atom bomb dropped on Hiroshima!!)

Earthquakes are often classified into different groups based on their size (Table 1). Annual average number of earthquakes across the Earth in each of these groups is also shown in the table; it indicates that on an average one *great* earthquake occurs each year.

Table 1: Global occurrence of earthquakes

Group	Magnitude	Annual Average Number
Great	8 and higher	1
Major	7 – 7.9	18
Strong	6 – 6.9	120
Moderate	5 – 5.9	800
Light	4 – 4.9	6,200 (estimated)
Minor	3 – 3.9	49,000 (estimated)
Very minor	< 3.0	M2-3: ~1,000/day; M1-2: ~8,000/day

Source: <http://neic.usgs.gov/neis/eqlists/eqstats.html>

Intensity

Intensity is a *qualitative* measure of the actual shaking at a location during an earthquake, and is assigned as *Roman capital numerals*. There are many intensity scales. Two commonly used ones are the *Modified Mercalli Intensity (MMI) Scale* and the *MSK Scale*. Both scales are quite similar and range from I (least perceptible) to XII (most severe). The intensity scales are based on three features of shaking – perception by people and animals, performance of buildings, and changes to natural surroundings. Table 2 gives the description of Intensity VIII on MSK Scale.

The distribution of intensity at different places during an earthquake is shown graphically using *isoseismals*, lines joining places with equal seismic intensity (Figure 2).

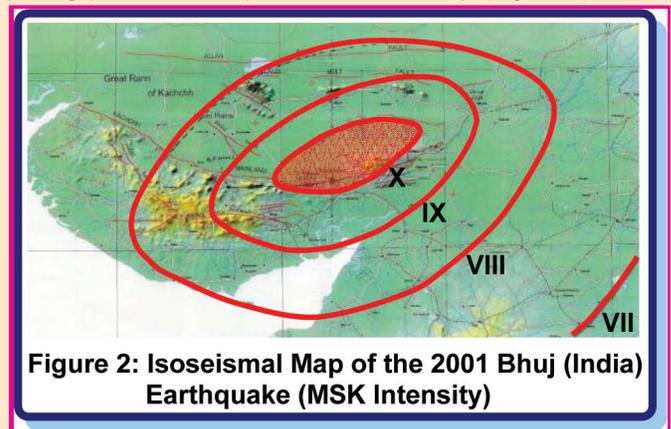


Figure 2: Isoseismal Map of the 2001 Bhuj (India) Earthquake (MSK Intensity)

Source: <http://www.nicee.org/nicee/EQReports/Bhuj/isoseismal.html>

Table 2: Description of shaking at intensity VIII as per MSK scale

Intensity VIII - Destruction of Buildings

(a) Fright and panic. Also, persons driving motorcars are disturbed. Here and there branches of trees break off. Even heavy furniture moves and partly overturns. Hanging lamps are damaged in part. (b) Most buildings of Type C suffer damage of Grade 2, and few of Grade 3. Most buildings of Type B suffer damage of Grade 3, and most buildings of Type A suffer damage of Grade 4. Occasional breaking of pipe seams occurs. Memorials and monuments move and twist. Tombstones overturn. Stonewalls collapse. (c) Small landslips occur in hollows and on banked roads on steep slopes; cracks develop in ground up to widths of several centimeters. Water in lakes becomes turbid. New reservoirs come into existence. Dry wells refill and existing wells become dry. In many cases, changes in flow and level of water are observed.

Note :

- *Type A structures* - rural constructions; *Type B* - ordinary masonry constructions; *Type C* - Well-built structures
- *Single, Few* – about 5%; *Many* – about 50%; *Most* – about 75%
- *Grade 1 Damage* – Slight damage; *Grade 2* – Moderate damage; *Grade 3* – Heavy damage; *Grade 4* – Destruction; *Grade 5* – Total damage

Basic Difference: Magnitude versus Intensity

Magnitude of an earthquake is a measure of its size. For instance, one can measure the size of an earthquake by the amount of strain energy released by the fault rupture. This means that the magnitude of the earthquake is a *single* value for a given earthquake. On the other hand, *intensity* is an indicator of the severity of shaking generated at a given location. Clearly, the severity of shaking is much higher near the epicenter than farther away. Thus, during the same earthquake of a certain magnitude, different locations experience different levels of intensity.

To elaborate this distinction, consider the analogy of an electric bulb (Figure 3). The illumination at a location near a

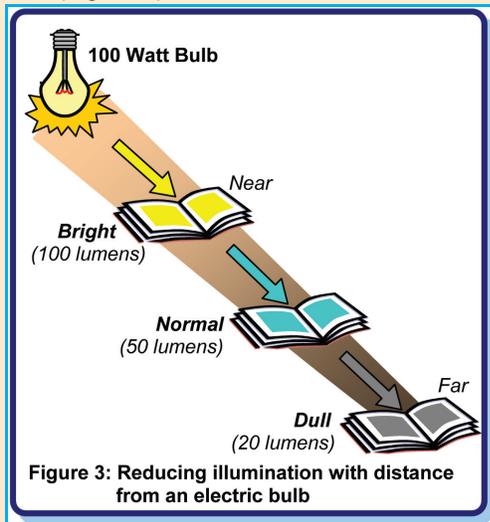


Figure 3: Reducing illumination with distance from an electric bulb

100-watt bulb is higher than that farther away from it. While the bulb consumes 100 watts of energy to produce light, the intensity of light (or illumination, measured in lumens) at a location depends on the wattage of the bulb and its distance from the bulb. Here, the size of the bulb (100-watt) is like the magnitude of an earthquake, and the illumination at a location like the intensity of shaking at that location.

Magnitude and Intensity in Seismic Design

One often asks: *Can my building withstand a magnitude 7.0 earthquake?* A magnitude 7.0 earthquake causes different shaking intensities at different locations, and the damage induced in buildings at these locations is different. Thus, it is a particular intensity of shaking that buildings and structures are designed to resist, and not so much a particular magnitude. The *peak ground acceleration (PGA)*, i.e., maximum acceleration experienced by the ground during shaking, is one way of quantifying the severity of the ground shaking. Approximate empirical correlations are available between the MMIs and the PGA that may be experienced (e.g., Table 3). For instance, during the 2001 Bhuj earthquake, the area enclosed by the isoseismal VIII (Figure 2) may have experienced a PGA of about 0.25-0.30g. However, now strong ground motion records from seismic instruments are relied upon to quantify destructive ground shaking. These are critical for cost-effective earthquake-resistant design.

Table 3: PGAs during shaking of different intensities

MMI PGA (g)	V	VI	VII	VIII	IX	X
	0.03-0.04	0.06-0.07	0.10-0.15	0.25-0.30	0.50-0.55	>0.60

Source: B.A.Bolt, Earthquakes, W.H.Freeman and Co., New York, 1993

Based on data from past earthquakes, scientists Gutenberg and Richter in 1956 provided an approximate correlation between the Local Magnitude M_L of an earthquake with the intensity I_0 sustained in the epicentral area as: $M_L = \frac{2}{3} I_0 + 1$. (For using this equation, the Roman numerals of intensity are replaced with the corresponding Arabic numerals, e.g., intensity IX with 9.0). There are several different relations proposed by other scientists.

Resource Material

1. Richter, C.F., (1958), *Elementary Seismology*, W. H. Freeman and Company Inc, San Francisco, USA. (Indian Reprint in 1969 by Eurasia Publishing House Private Limited, New Delhi)
2. http://neic.usgs.gov/neis/general/handouts/magnitude_intensity.html

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Recent Developments in Science and Technology

Potent vaccine from irradiated pathogens

A vaccine is usually a preparation of a weakened or killed pathogen, such as a bacterium or virus, or of a portion of the pathogen's structure that when inoculated stimulates antibody production or cellular immunity against the pathogen but is incapable of causing severe infection. The term derives from *vaccinia*, the infectious viral agent of cowpox, which, when administered to humans, provided them protection against smallpox, as observed by an English country doctor, Edward Jenner in 1796. But vaccines prepared by conventional methods have certain limitations. For example, vaccines from weakened microbes require constant refrigeration until use, and those from microbes killed by heat or chemicals provoke a weaker immune response, requiring occasional boosters. Now researchers in USA have found that vaccines produced from microorganisms killed using gamma radiation can trigger powerful immunity.

Sandip Datta of the University of California, San Diego, USA and his colleagues have found that when *Listeria monocytogenes* – bacteria found in food that can cause health problems for mothers and babies – were irradiated with strong doses of gamma rays it failed to grow in a culture medium. But when injected into ten mice, the irradiated bacteria helped keep eight of them alive after they were exposed to a dose of live *Listeria* that killed 20 other mice, proving the high efficacy of the technique. In fact, the irradiated vaccine was found to be able to trigger a long-lasting immunity in its host; the mice were still resistant to *Listeria* more than a year after vaccination. A freeze-dried version of the irradiated vaccine also proved effective, raising hopes for versions that would be easy to store, transport and reconstitute on site.

Source: www.sciam.com

Gold producing bacteria discovered

Gold is one of the few elements that occur free in nature. Naturally occurring pieces of gold known as nuggets are often found in riverbeds as tiny beads and are collected by panning. But where do the gold grains come from? Now Australian researchers have found the source: soil bacteria. Geomicrobiologist Frank Reith of the Commonwealth Scientific and Industrial Research Organisation in Adelaide, Australia and his colleagues have discovered soil bacteria that can extract dissolved gold and turn it into the precious metal. They collected grains of gold from two mine sites 3,400 kilometres apart. On the nearly pure grains of gold they found striking examples of "bacteriform" gold (gold formed by bacteria) overlain by biofilms of bacteria and their exuded slime. The bacterium was found to be almost identical to *Ralstonia metallidurans*, a microbe well known for its ability to precipitate some heavy metals from solution in the lab. Reith and his colleagues showed that *R. metallidurans* could also precipitate gold from solution. This discovery opens up the possibility of using the ability

of these bacteria to concentrate gold around their cell membranes for extracting gold from sea water of the Earth's oceans, which is estimated to contain about 709,000 tonnes of gold. At only 10 parts per billion, the concentration of gold in sea water is too low to make conventional methods of extracting gold from sea water economically viable.

Source: *Science*, 14 July 2006

Methane lakes on Titan

Saturn's largest moon Titan has lakes of liquid methane. This conclusion was reached by a team of scientists after analysis of radar data sent back by the *Cassini* spacecraft which has been in orbit around Saturn since 1 July 2004. This makes Titan the only other body in the solar system, besides Earth, known to have standing bodies of liquid on the surface. Earlier, evidence of methane clouds, methane rain, and valleys cut by rivers of liquid methane had been found on Titan from *Cassini* data. The methane lakes range in size from two kilometres to 30 kilometres across. The planetary radar specialist Donald Campbell of Cornell University, New York, USA and his team believe that the methane lakes may be the last link in the "methane cycle" of Titan, similar to the "water cycle" on Earth.

Source: *Science*, 4 August 2006

Obituary

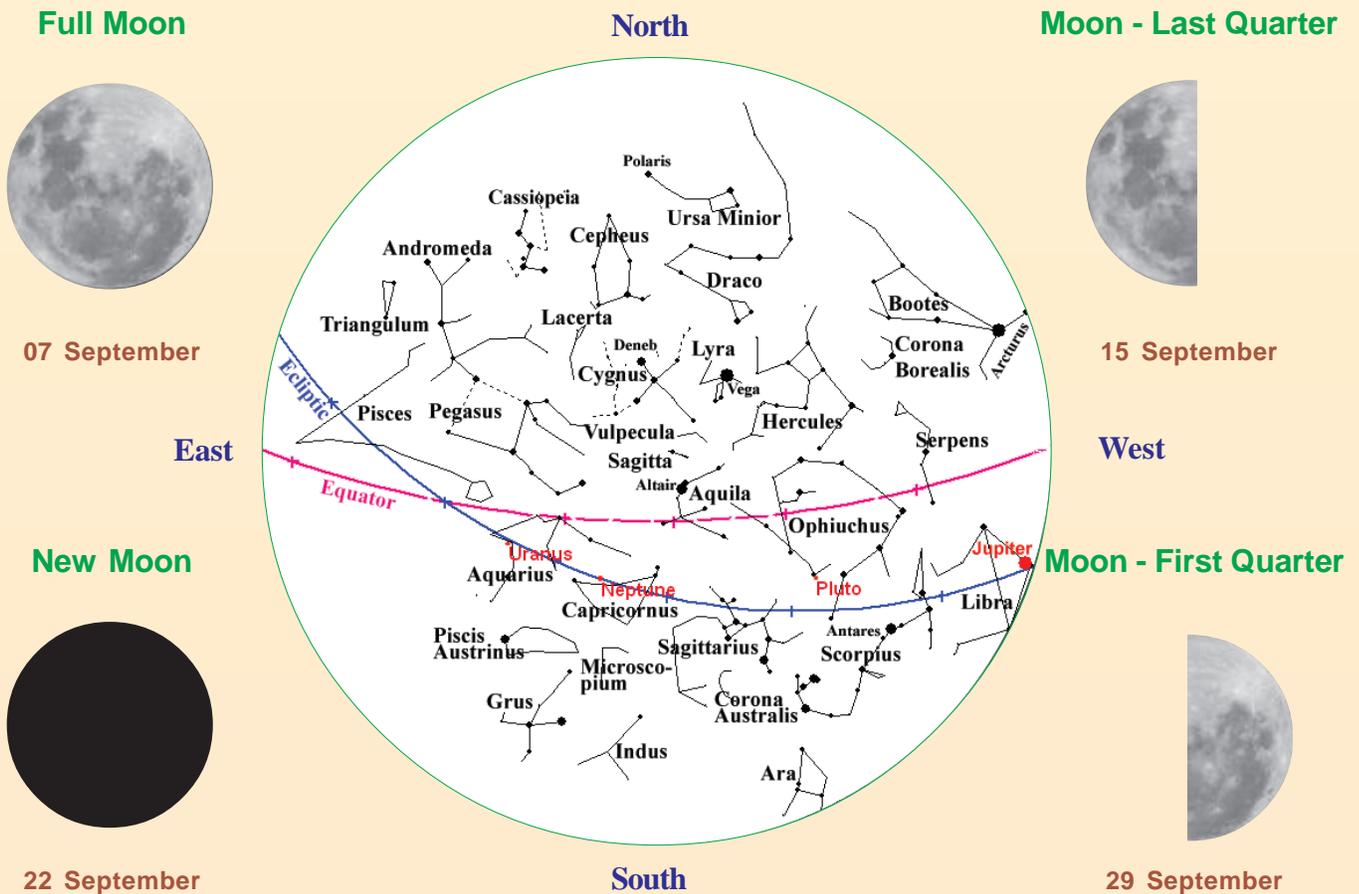
James Van Allen (1914-2006)

James Van Allen, American physicist whose discovery of the radiation belts around the Earth brought about new understanding of cosmic radiation and its effects upon the Earth, passed away on 9 August 2006 in Iowa City, Iowa, USA at the age of 91. He was one of the scientists who proposed a program of worldwide cooperation in research, the International Geophysical Year (IGY) of 1957–58 and suggested the use of Geiger counters on the Earth-orbiting satellites to detect radiation. The instrumentation of the early *Explorer* satellites, part of the United States' IGY program, was built by Van Allen and his associates. The information on cosmic radiation gathered by these satellites led to the discovery of the Van Allen radiation belts – two belts of radiation outside the Earth's atmosphere, extending from about 650 km to 65,000 km above the Earth's surface. Even before the radiation-belt discovery, Van Allen was deeply involved in early American rocket research. When, in April 1945, a V-2 rocket captured from the Germans was first sent aloft from the White Sands Proving Ground in New Mexico, it carried Geiger counters provided by Van Allen. His goal was to record radiation from space before it was altered by passage through the atmosphere. Van Allen later participated in the development of numerous space probes built to study planetary and solar physics.

Born on 7 September 1914 in Mt. Pleasant, Iowa, USA, Van Allen was a long time professor of physics and astronomy at the University of Iowa and wrote numerous papers and journal articles. He also edited *Scientific Uses of Earth Satellites* (1956) and was an associate editor of the *Journal of Geophysical Research* (1959–64), and *Physics of Fluids* (1958–62). He was elected to the US National Academy of Sciences in 1959 and became president of the American Geophysical Union in 1982.



Sky Map for September 2006



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 31 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 Round Up :

Jupiter: In the constellation Libra (Tula Rashi) at Western horizon.

Uranus, Neptune and Pluto: Not a naked eye object. Hence not visible.

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

Eastern sky: Pisces/Meen Rashi, Triangulum, Pegasus/Mahashva, Andromeda/Devayani, Sculptor.

Western sky: Libra/Tula Rashi, Bootes (Arcturus)/Bhutaap (Swati), Serpens, Ophiuchus/Bhujangdhari, Corona Borealis/Uttar Mukut, Hercules/Shauri.

Southern sky: Ara, Indus, Corona Austrina, Scorpius (Antares)/Vrischik (Jeshta), Sagittarius/Dhanu Rashi, Microscopium, Grus, Piscis Austrinus.

Northern sky: Ursa Minor (Polaris), Cassiopeia/Dhanishta, Cepheus/Vrishapurv, Draco/Kaleea.

Zenith: Aquila (Altair)/Garuda (Sravan), Cygnus (Deneb)/Hansa (Hansa), Lyra (Vega)/Swaramandal (Abhijeet), Capricorns/Makar Rashi.

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