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ISRO Discovers Bacteria in the Stratosphere

Āryabhata
The Greatest Astronomer of Ancient India

Inside

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

The Web Turns 20

13 March 2009 (Friday) marked the 20th anniversary of the World Wide Web. In March 1989, Tim Berners-Lee, then a little-known computer scientist, wrote a proposal entitled "Information Management: A Proposal". He was then working as a consultant at CERN (European Organisation for Nuclear Research - now called the European Laboratory for Particle Physics), near Geneva. Mike Sendall, his supervisor, described it as "vague, but exciting", but, later gave it the go ahead, although it took a good year or two to get off the ground. It was this proposal that paved the way for the World Wide Web and the consequent information explosion we are familiar with today.

Indeed, it is difficult to think of life without access to Internet! Be it access to or sharing of data files and documents, e-mail, banking, chat, news, job hunting, product info, shopping on the net, entertainment, contests, rail or air tickets, downloading software or games, matrimonial alliance and so on - the list is growing! The Internet is the transport vehicle for the information stored in files or documents of another computer. It would, however, be a misstatement when one says, "I found the information on the Internet!" In fact, what one means is that the document was found through or using the Internet on one of the computers *linked* to the Internet. The Internet itself does not contain any information. Rather, it is the World Wide Web (WWW or the Web, as it is popularly known today) that incorporates all of the Internet services mentioned above, and much more. The Web helps retrieve documents, view images, animation and video, listen to sound files, speak and hear voice, and view programmes that run on practically any software in the world provided our computer has the hardware and software to do these things.

How did it all begin? Let us first briefly consider the development of the Internet that paved the way for the Web. It was in 1960s that Pentagon, headquarters of the United States Department of Defence, embarked upon an ambitious project through its agency ARPA (Advanced Research Project Agency) to develop a network of computers in which one computer could communicate with another. The nodes of the network were to be high-speed computers which were in real need of good networking for the national research projects and other development programmes. By December 1969, an infant network came into being with just four nodes, called ARPANET. The four computers could transfer data on dedicated high-speed transmission lines. They could even be programmed remotely from other nodes. Scientists and researchers could share one another's computer facilities over long distance. In 1971, there were 15 nodes in ARPANET, and in 1972 there were 37. TCP or Transmission Control Protocol converted messages into streams of packets at the source, and then reassembled them back into messages at the destination. IP or Internet Protocol handled the addressing; seeing to it that the packets are routed across multiple nodes and even across multiple networks with multiple standards.

ARPANET itself expired in 1989. However, as the 1970s and 1980s advanced, with availability of more powerful computers, it became fairly easy to link the computers to the growing network of networks. Since the software (network protocol) called TCP/IP was public domain, and the basic technology was decentralised, it was difficult to stop people from barging in, linking up somewhere or the other. This is what came to be known as the "Internet". The nodes in the growing network of networks were divided up into basic varieties, say, gov, mil, edu, com, org and net. Such abbreviations are a standard feature of the TCP/IP protocols. The use of TCP/IP standards is now global.

What was the situation prior to 1989? The Internet only provided screens full of text, usually only in one font and font size. Surely, it was good for exchanging information, and even for accessing information such as the library catalogues. But, it was visually very boring. Graphical User Interfaces (GUI) added a bit of colour and layout giving it a slightly better look. In the mid-eighties, personal computers were just beginning to adopt Windows interfaces. One of the significant predecessors of the Web was the *Xanadu* project, which worked on the concept of *hypertext*, or the machine-readable text that is organised so that related items of information are connected. Clicking on a *hyperlink* (a word from a

Contd. on page...25

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Âryabhata

The Greatest Astronomer of Ancient India

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"The importance of Âryabhata lies in the fact that he probably was in the vanguard of the new astronomical movement which resulted in the recasting of this branch of knowledge about fifth century AD. Piecemeal efforts might have started earlier, as is evident from Varâhâmihira's account of five *siddhantas*, and before and about the time when Âryabhata flourished there were certainly astronomers of repute who were variously engaged in reforming astronomy, but little is known about their contributions as their works have not survived. As matters stand, the *Aryabhatîya* is the earliest astronomical text bearing the name of an individual of the scientific period of Indian astronomy."

- S. N. Sen in *"A Concise History of Science in India*", Indian National Science Academy, New Delhi, 1989

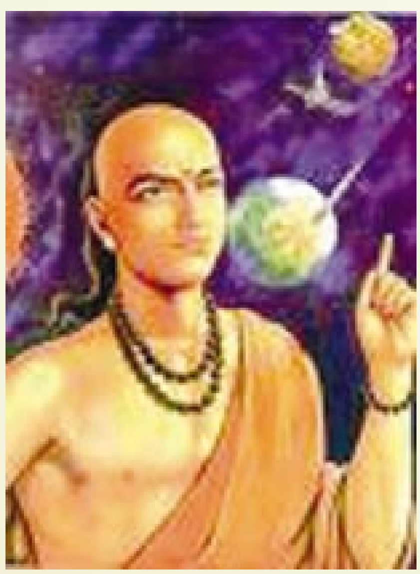
"The names of several astronomers who preceded Âryabhata, or who were his contemporaries, are known, but nothing has been preserved from their writings except a few brief fragments. The *Aryabhatiya*, therefore, is of the greatest importance in the history of Indian mathematics and astronomy."

- Walter Eugene Clark, who brought out a definitive translation of *Aryabhatiya* into English (quoted from Henry Scolberg's *The Biographical Dictionary of Greater India*).

"Like all ancient astronomy, that of India was restricted owing to ignorance of the telescope; but methods of observation were perfected which allowed very accurate measurement, and calculations were aided by decimal system of numerals. We know of no remains of observatories of the Hindu period, but those of the 17th and 18th centuries, at Jaipur, Delhi and elsewhere, with their wonderfully accurate instruments constructed on an enormous scale to minimize error, may well have had their ancient counterparts."

- A. L. Basham in *The Wonder that was India*, London, 1954

Ancient Indians had shown great proficiency in astronomy since Vedic times. Âryabhata described his astronomical ideas in his celebrated treatise. *Aryabhatiya* (also called *Aryabhatiyam*). This work laid the foundation of *Âryabhata Siddhantic* School of Astronomy. Âryabhata is one of the most important figures in the history of India's astronomy. Commenting on the status of Indian astronomy at the time of Âryabhata, M. L. Sharma of Sampuranand Sanskrit University, Varanasi, wrote: "...at the time of Âryabhata, Indian astronomy had reached that state of development where it possessed all mathematical, astronomical and instrumental knowledge which was ideal for the higher study of astronomy. To reach that state of development a lot of time was needed. So the beginning of *Siddhanta* astronomy in India must have taken place much earlier than it is usually supposed. It may be said that Indian astronomy was facing problem also at that time. In this background of astronomical knowledge we enter the period of Âryabhata."



Âryabhata

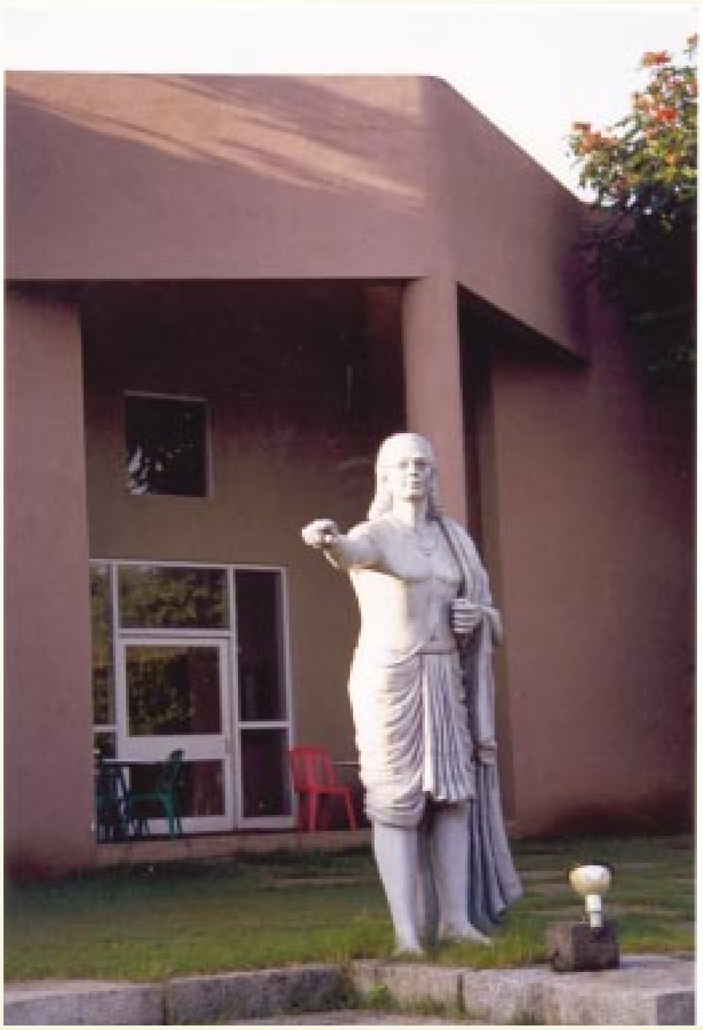
Âryabhata was the first Indian astronomer to propose the rotation of Earth to explain the daily westward motion of the stars in the sky. He stated that rising and setting of the Sun, the Moon and other heavenly bodies are due to the relative motion caused by the Earth's rotation about its axis once a day. He introduced many new concepts such as an alphabetical system of expressing numbers, rules for extraction of squares and cube roots, construction of trigonometric sine tables and eccentric-epicentric models of planetary motion. He worked out the value of pi (π) as 3.1416 for the first time in India, which is correct to the first four decimal places. He knew that the value given by him was '*asanna*'; that is, approximate. This is because pi is irrational or incommensurate. He also

History of Science

believed that eclipses were caused by the shadows of the Moon and the Earth and not by *Rahu-Ketu* as it was believed. Âryabhata was aware of the spherical shape of the Earth.

Almost nothing is known of his life. His name is sometimes spelled as "Âryabhatta". It may be noted that there is another astronomer of the name of Âryabhata who lived in tenth century AD To distinguish the two, they are called Âryabhata I and Âryabhata II (c. 950). Âryabhata II was basically a compiler and he was an adherent to orthodox views. Arabic scholars referred to Âryabhata as *arjabhar* or *ajabhar.* Abu Raihan Muhammad ibn Ahmad Al-Biruni (973-1048) [usually referred to simply as Al-Biruni] wrote: "They (Alfazari and Y'kub) apparently did not understand him and imagined that Âryabhata means a 'thousandth part'". Al-Biruni, a mathematician and astronomer of some repute came to India in the eleventh century. He travelled to India during 1017 and 1030 as a political hostage with Mahmud of Ghazni (971-030), the first sultan of the Ghaznavi dynasty in Afghanistan, in course of the latter's invasion of India.

Earlier scholars thought that Âryabhata was either born in Kusumpura, a suburb of Pataliputra (modern Patna) or taught there. Some scholars identified Kusumpura with Pataliputra. Âryabhata himself in one of the verses of the *Ganitapada* stated: "he (Âryabhata) sets forth in his work the science which is held in high esteem at Kusumpura." However, recent studies on the works of Bhasakara, the greatest exponent of Âryabhata's system of astronomy and other medieval commentators of Âryabhata, reveal that earlier held belief of scholars is not correct. In these works, Âryabhata is often referred to as *âœmaka* that is one who comes from Âúmaka region located in southern India, possibly in modern-day Kerala, and his works *Âúmaka sphutatantra*. Another fact which supports the view that Âryabhata came from Kerala is that most of the commentaries of *Âryabhatiya* and works based on it have come largely from southern India, especially from Kerala. Further, majority of the astronomers belonging to the Âryabhata School come from South India.



Aryabhatta's statue at Central Kund - IUCAA campus

Âryabhata wrote *Âryabhatiya* at the age of 23 (499). This was lost and a revised version was written later. Bhau Daji (1822-1874), a famous physician and an Indologist based on his serious studies published a paper on Âryabhata in the *Journal of Royal Asiatic Society*, in 1865. A revised Sanskrit version of *Âryabhatiya* was published by J. H. C. Kern in Leiden, Holland, in 1874. A French translation was published in 1879. A definitive English translation of this work was prepared by Walter Eugene Clark, a Sanskrit professor of the Harvard University and it was published by the Chicago University Press in 1930. It may also be noted that *Âryabhatiya* was translated into Latin in the 13th century by an Italian mathematician.

According to Clark, *Âryabhatiya* is "the earliest preserved Indian mathematical and astronomical text bearing the name of an individual author, the earliest Indian text to deal specifically with mathematics, and the earliest preserved astronomical text…of Indian astronomy." There were many other works on astronomy written before Âryabhata, but we do not know the names of their authors.

Âryabhatiya is written in verse couplets. It is a small work containing about 121 s*lokas* or stanzas. It is divided into four sections called *padas*, viz., *Gîtikâpâda*, *Ganitapâda*, *Kâlakriyâpadâ* and *Golanâda*.

The *Gitikapâda* is the shortest of the four sections. It has 13 stanzas including the verses meant for dedication and conclusion. Out of the 13 stanzas 10 are in *Gitika* metre and that is why it is known as *Dashagitika*. "One who knows these verses, one who knows the movements of planets and *naksatras*, goes much beyond them and attains the Absolute Brahman." says the author. In this section the basic definitions and important astronomical parameters and tables are given. It also explains the rules of a unique method of writing numbers in Sanskrit alphabet.

The *Ganitapâda* deals exclusively with mathematics. It has 33 stanzas. The topics covered in this section include *varga* (squares), *ghana* (cubes), *vargamula* (square-roots), *ghanamula* (cube-roots), area of a triangle and volume of a prism, area of a circle and volume of a sphere, area of a *visamacaturasa* (quadrilateral), circumference of a circle, *bahu* (the base of a right-angled triangle), and *koti* (the upright of the right-angled triangle), *karna* (hypotenuse of the right-angled triangle), *trairasika* (rule of three), *vyasta* (reverse rule of three) and *kuttakara-ganita* (the theory of pulveriser).

The remaining two sections, *Kâlakriyâpâda* and *Golapada* deal with astronomical principles and methods of computations in very condensed form. The section *Kâlakriyapada*, which means reckoning of time, has 25 stanzas. It includes topic like division of time and the circle, definitions of solar year, lunar month, civil day, sidereal day, intercalary months, omitted lunar days, planetary orders and movements, the eccentric-epicyclic models, use of these models for the calculations of the true planetary positions from the Earth and other related topics.

The *Golapâda* is the longest section and it is for this section Âryabhata is most famous. *Gola* means sphere. It has 50 stanzas. In this section Âryabhata explains the methods of representing planetary motions in a celestial sphere. He also defines such terms like prime vertical, meridian, horizon, hour circle, equator, parallax, and ecliptic. He discusses the *pata* (ascending nodes) of the planets and the shadow of the Earth movement on the path of the Sun (*arka-apanamandala*). Âryabhata asserts that the Earth is the centre of the universe and it revolves around its axis. In fact, Âryabhata was the first Indian astronomer to consider the rotation of the Earth for explaining the apparent daily motions of the fixed stars. But his idea did not find support among his contemporaries or later astronomers. It was not unexpected, as in those days the prevailing belief was that the Earth was not only at the centre of the universe but it was fixed.

The system of astronomy taught in *Âryabhatiya* is usually referred to as the *audayika* system because the day beginning is reckoned from the mean sunrise (*udaya*) at Sri Lanka, a place situated close to the Earth's equator. Âryabhata was also the originator of another system of astronomy called *ardharatrika* in which the day beginning is reckoned from the mean midnight (*ardharatri*) at Lanka (Sri Lanka). Varahamihira wrote: "Âryabhata maintains that the beginning of the day is to be reckoned from midnight at Lanka; and the same teacher again says that the day begins from sunrise at Lanka." Brahmagupta in his *Brahmasphuta-siddhanta* talks about these two systems of astronomy described by Âryabhata. Brahmagupta himself followed the *ardharatrika* system.

Varahamihira

Âryabhata was severely criticised by several of his contemporaries and astronomers who followed him. Thus Brahmagupta commenting on Âryabhata wrote: "Since Âryabhata knows nothing of mathematics, celestial sphere or time, I have not mentioned separately his demerits." Further as S. N. Sen writes: "Brahmagupta attacked Âryabhata for dividing the *yuga* into four equal parts, for upholding the rotatory motion of the Earth, for believing in the eclipses being caused by the shadows of the Moon and the Earth and not in accordance with the traditional *Rahu-Ketu* theory." Al-Biruni was apparently not convinced with Brahmagupta's views on Âryabhata. Thus he writes "He (Brahmagupta) is rude enough to compare Âryabhata to a worm which, eating the wood, by chance describes certain characters in it, without understanding them and without intending to draw them. In such offensive terms he attacks Âryabhata and maltreats him…" Al-Biruni not only noticed undue criticism of Âryabhata but he also acknowledged the merit of his ideas.

Brahmagupta was an important astronomer in his own right. It may be noted that Brahmagupta's attitude towards Âryabhata changed with time. The abovementioned highly critical remarks were written by him in *Brahmasphuta-siddhanta*, composed at the age of 30. However, his *Khandakhadyaka*, composed at the age of 67 was primarily based on Âryabhata's *ardharatrika* system. It may be noted that Brahmagupta's works were translated into Arabic by Muhammad ibn Ibrahim al-Fazari (died 796 or 800) and Ya'qub ibn Tariq (died 796) as *Sindhind* (a translation of *Brahmasphuta-Sidhanta*) and the *Arakand* (a translation of *Khadakhadyaka*).

Commenting on the contributions of Âryabhata, the noted Indian astrophysicist J. V. Narlikar writes: "Âryabhata gives a table of the trigonometric sine functions, calling them *jya* in Sanskrit. The table gives the sines of angles at intervals of 3°45'. The sine tables are needed to work out the geometrical measurements of positions of stars and planets on the celestial sphere. Thus we see that Âryabhata was conversant with the notions of spherical trigonometry. Moreover, at the conceptual level, his awareness of the spherical shape of Earth and its spin around an axis reflect how advanced he was with respect to his contemporaries. For example, he argues in one verse of the *Âryabhatiya* that although the stars appear to go westwards, they are in fact fixed and we are observing them from the moving platform of the spinning Earth."

The names of Pandurangasvami, Latadeva, Prabhakara and Nihsanku are cited as direct disciples of Âryabhata. However, it was Bhâskara I (c. 600), who contributed greatly in propagating Âryabhata's work. "Aryabhata's cryptic and aphoristic style would have made it extremely difficult to understand his text, but for the detailed exposition of the system by Bhaskara (c. 600)", writes S. Balachandra Rao. Bhâskâra did it by his excellent commentaries and his own independent work. He was a contemporary of Brahmagupta. Bhâskara was a native of either western India or South India (possibly Kerala). He was associated with both these regions. So it might be that he was a native of either of these two regions and migrated to the other. His major work, the *Mahâbhâskariya*, was an elaborate exposition of the three astronomical chapters of *Âryabhatiya.* As S. N. Sen has described in *A Concise History of Science in India*, it consisted of eight chapters dealing with following topics:

1. Mean longitude of planets and indeterminate analysis.
2. Longitude correction.
3. Time, place and direction, spherical trigonometry, latitudes and lunar eclipses.
4. True longitudes of planets.
5. Solar and lunar eclipses.
6. Rising, setting and conjunction of planets.
7. Astronomical constants.
8. *Tithi* and miscellaneous examples.

Bhâskara introduced many new methods of his own. While Âryabhata postulated rules for indeterminate analysis, it was Bhâskara who elaborated it and its application to astronomy. Bhâskara prepared an abridged version of his main work known as *Laghubhaskariya*. It may be noted that another astronomer named Bhâskara and to distinguish them they are called Bhâskara I and Bhâskara II. The latter was born around 1114 and his major work was *Siddhânta-siromani*, which was divided into four chapters, viz., *Lilavati* (on arithmetic), the *Bijaganita* (on algebra), *Ganitadhyay* and the *Goladhayaya* (the last two on astronomy).

The works and teachings of Âryabhata exerted strong influence on later generations of astronomers in India. A long line of his followers propagated his views through their excellent commentaries.

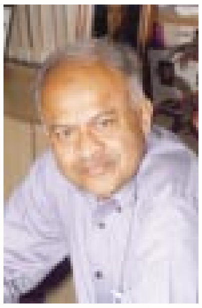
The first Indian-built satellite launched by a rocket of erstwhile Soviet Union in April 1975 was named after Âryabhata.

References

1. Bose, D. M., S. N. Sen and B. V. Subbarayappa (Eds.), *A Concise History of Science in India*, New Delhi, Indian National Science Academy, 1989.
2. Scolberg, Henry, *The Biographical Dictionary of Greater India*, New Delhi: Promilla & Co., Publishers, 1998.
3. Narlikar, Jayant V., *The Scientific Edge: The Indian Scientist from Vedic to Modern Times*, New Delhi: Penguin Books India (P) Ltd., 2003.
4. Basham, A. L., *The Wonder that Was India*, New Delhi: Picador India, 2004. (first published in London in 1954 by Sidgwick & Jackson).
5. *Al-Biruni's India* (edited with introduction and notes by Oeyamuddin Ahmed), New Delhi: National Book Trust, India 1995. This is an abridged edition of Edward' C. Sachan's English translation of Al-Biruni's Tarikhu's Hind.
6. Rao, S Balachandra, *Indian Astronomy: An Introduction*, Hyderabad: Universities Press (India) Ltd., 2000.
7. Sharma, M.L., "Aryabhata's Contribution to Indian Astronomy", *Indian Journal of History of Astronomy*, Vol.12, No.2, pp.90-99, 1977.
8. Sharma, M.L., "Indian Astronomy at the Time of Aryabhata", *Indian Journal of History of Astronomy*, Vol.12, No.2, pp.100-105, 1977.
9. Behari, Ram, "Aryabhata as a Mathematician", *Indian Journal of History of Astronomy*, Vol.12, No.2, pp.90-99, 1977.

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

Why Study Astronomy?



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I am an astronomer and astrophysicist by profession and I thought that I can use this opportunity to share with you the thrill and excitement of working in this field, to show how new unexpected challenges come in the way and how they are met. Also, to those who are not in this field and who wonder what the use of star gazing and trying to understand cosmic phenomena could be, I would like to convey how an apparently esoteric field like this one can bring benefits, not only to the scientist but also to society at large.

Indeed, astronomy began as a science as much through human fascination about the Cosmos as through the realisation that observing the sky can bring in knowledge that is *useful* to society. For, the stars and constellations change their position in the sky as time passes, and by observing these patterns one can make calendars. The observed changes in the position of the Sun and the Moon were thus used to tell how the time progressed. And it was observed that these changes were cyclical, with the period of what became known as *one year*.

To the agriculturist, it was important to know how the seasons progressively change through the year, so that the different stages of sowing, growing and harvesting crop could be carried out at the right time. Even today the *nakshatras* guide the farmer in such operations.

To the Indian society, of course, astronomy provided information on determining the so-called 'auspicious' times for performing the various rituals, as these times were linked to the positions of heavenly bodies in the sky. In fact considerable progress of mathematics in the early times is linked to the rituals like *yajnas*. Astronomy made its own contributions to these events.

Finally, sailors on the high seas realised that stars in the sky provided them with vital clues on directions and thus helped in navigation. Thus they learnt to 'read the sky' as a practical solution to their navigational problems.

From Kepler to the modern times

However, let us move on to more recent times and consider the motions of planets. The Greeks used the word 'planet' in the sense of its meaning: *wanderer*; because they did not, or could not, see a prima-facie pattern in their motions. Guided as they were by the natural philosophy of Aristotle, they tried to fit the heavenly bodies into a pattern of circular motions. For, Aristotle believed that all *natural motions* are circular; and any departure from circular path indicates that there is a disturbing agency. This latter type of motion he termed *violent motion*.

Now star trajectories across the sky fell into neat circular arcs from East to West. This was consistent with Aristotle's natural motions. The planets, however, did not show such simplicity. Relative to stars, their paths were twisted, sometimes reversing, sometimes going up or down, relative to the path of the Sun, say. The planets therefore were *wanderers*.

It is probably because of this extraordinary nature of planetary tracks that belief grew that the planets possessed extraordinary powers, which they wielded on the mortals on Earth. The age-old belief in astrology may be understood this way. I will return to this aspect later.

To their credit, the Aristotelians did not content themselves with this belief and sought to fit the wayward planetary trajectories into the circular pattern. Thus grew the concept of *epicycles*. Instead of a single circle, the planet, so it was argued, moved on a circle whose centre moved on another circle, whose centre moved on still another circle, and so on…It depended on the skill of the geometer and the required accuracy of the model vis-à-vis observations as to how far this process would go! These circles came to be known as epicycles and the theory the epicyclic theory.

In short, to understand the somewhat arbitrary motions of planets was a challenge to the Greek astronomers two thousand years ago and they tried to meet it through the intricate geometric constructions of epicycles. In the terminology of the modern theoretical physicist, their theory had epicycles as parameters and to achieve the desired accuracy the number of parameters had to be increased.

The Greek obsession with circles, looked at this way, was conditioned by the wrong Aristotelian belief in circular motion. It was further complicated by the geocentric theory that supposed that the Earth is fixed in space and that all planets and the Sun move around it. Nicolaus Copernicus got rid of the latter but retained the former. That is, although he assumed that the Earth, along with other planets goes round a fixed Sun, he still retained the epicycles. This made his geometrical constructions somewhat simpler but still not elegant; the epicycles were a reminder that this was a wrong way of looking at reality.

This is where we appreciate the contributions of Johannes Kepler. He was keen to work on planetary trajectories to look for an underlying simplicity of their construction. He was aware that this required detailed observational studies and such observations had been carried out by the Danish astronomer Tycho Brahe. So he enrolled with Tycho as an assistant.

Tycho himself was convinced that the heliocentric theory of Copernicus was wrong and hoped that his own data would disprove it. He was in need of an assistant and was glad to enrol Kepler as one.

Working with Tycho was not, however, a pleasant experience what with his whimsicality and demeaning behaviour towards his assistant. But Kepler stuck to it, as Tycho's data was a veritable goldmine. As luck would have it, Tycho died not long after Kepler joined him and on his deathbed enjoined his assistant to do his best to disprove Copernicus.

After Tycho's death, while his relatives were arguing over his possessions, Kepler quietly took hold of the valuable data and spent the next two decades carefully analysing it. And out of these efforts emerged the three laws of planetary motion that are now named after him. In a sense Tycho kept his promise to Tycho: he proved Copernicus wrong; but not in the sense that Tycho had intended. Kepler verified that the heliocentric theory was correct, although the Copernican epicyclic approach was wrong.

Kepler's first law of motion sets out this clearly. It tells us that a planet goes round the Sun in an elliptical trajectory. The Sun is at the focus of the ellipse. Thus the series of epicycles represented an approximation to the reality of an ellipse. Kepler's second law describes *how* a planet moves along its path: the line joining it to the Sun sweeps out equal areas in equal intervals of time. And his third law relates the period of the planet completing one orbit to the *size* of the orbit.

I have gone into these details because the emergence of these simple looking rules demonstrates the result of Kepler's persistent efforts. Out of the noise he had picked up the real signal which all his predecessors had missed. *He had discovered the pattern of planetary motion.* More importantly, the stage was now set for asking the question *'Why do the planets move around the Sun in this way?'*

It required the genius of Isaac Newton to answer this question. We read the story of how Newton discovered the law of gravitation when an apple fell on him while sitting in his orchard at Woolsthorpe Manor during his *anni mirabilis*, 1664-1666. Could the fall of an apple inspire an inverse square law? The story, if true, may go so far as suggesting that it led Newton to think of a force of attraction between the Earth and the apple. But nothing more. Even the most sensitive instruments of today's technology cannot tell us that the fall of an apple implies the inverse square law of attraction. For this quantitative deduction, Newton needed more detailed data and those were available to him in Kepler's work.

Today a mathematics undergraduate can deduce the inverse square law of gravitation from the three Keplerian laws. For Newton it was the work of a genius, as he used the calculus newly invented by himself for this work. Later he demonstrated the converse - that given the law of gravitation and the laws of motion, the Keplerian laws follow.

Thus by the end of the seventeenth century, the riddle of how the planets move and why they so move had been fully understood. Far from being wanderers moving at their own will, the planets were inert masses forced to move in well-defined trajectories by the Sun's force of attraction. If there was any justification for believing that planets wield any influence on us humans, that disappeared by this demonstration. Yet such is the human mind, that many still believe in that myth today, three centuries later!

Let me move on to the next step in the evolution of thought. Newtonian law of gravitation was inspired by Kepler's laws of planetary motion and received further confirmation through more astronomical observations, like Halley's Comet, the discovery of planet Neptune, the motions of binary stars, and so on. Although the famous experiment by Henry Cavendish measured the strength of the gravitational force in the laboratory, the confidence in the validity of the Newtonian law grew solely because of astronomical data.

Having said this we now come to the recent years of space technology. That we can launch satellites around the Earth or can send spacecrafts to the Moon and the planets like Mars, Mercury or Jupiter, all in highly precise trajectories is because of the validity of Newton's law. So the benefits we enjoy today from space technology be it remote sensing of Earth resources, or sending a fax or an e-mail message or watching the World Cup live on TV, all owe their existence to the law of gravitation; and the law of gravitation itself owes its genesis to the data from astronomy.

This brings me to the point I wish to underscore in this article, that astronomy may appear esoteric and remote from everyday life, but its pursuit leads to addition to human storehouse of knowledge that brings benefits to human societies.

The source of solar energy

I now turn to another example, to the age-old problem of what keeps the Sun shining. This question has been a major challenge to astrophysicists whose job it is to understand the behaviour of celestial bodies in terms of the laws of physics we know. Although the problem has now been solved, it is interesting to take a look at its history.

In the last century, two distinguished physicists, Lord Kelvin in Britain and Baron von Helmholtz in Germany offered a solution to the problem. They argued that the source of solar energy lies in its vast gravitational energy reservoir. In a gravity dam, water falling from a great height can run electric turbines and thereby transfer its gravitational energy to electric one. In the same way, Kelvin and Helmholtz demonstrated that as a massive ball of matter like the Sun slowly shrinks, it releases gravitational energy which can be converted to light energy.

On the face of it the calculation was impressive, as it showed that the Sun could draw on this energy for about twenty million years if it were to keep shining at its present rate. However, the idea did not work! For, by the turn of the century, it was becoming clear that the Earth and the Solar System was considerably older than twenty million years. Today we know that the age of the Solar System may be close to five *billion* years. Thus the gravity reservoir of the Sun is not adequate for keeping it shining for so long.

In the third decade of twentieth century, the problem of solar energy was tackled anew by the Cambridge astronomer Arthur Stanley Eddington. Eddington had set up equations describing the internal structure of a star like the Sun. These equations visualised the Sun as a ball of hot plasma, (that is, a system of atoms of gas from which the outer electrons have been stripped off and kept as a separate entity) which was held in equilibrium under the opposing forces of its own gravity and pressures of gas and radiation. They also showed how to describe the passage of radiation from deep interior to the outer layers of the star, eventually escaping as starlight.

Using these equations Eddington was able to estimate the march of pressure, density and temperature of the gas from the outer layers all the way towards the centre. All these rise rapidly as we proceed inwards. For example, a star like the Sun may have an outer surface temperature of 5,500 degrees, but its central temperature could well exceed ten million degrees!

Now, normally the nucleus of an atom is a tightly bound entity. In a typical chemical reaction the nucleus is not affected. However, at energies considerably in excess of chemical energies, at energies of particles in a gas of ten million degrees temperature, even the identity of a nucleus is threatened. In particular, it may be possible for two smaller nuclei to combine into a bigger one. This process is known as *nuclear fusion*.

Eddington believed that nuclear fusion would operate in the core of a star and, in particular, the process would result in the formation of the nucleus of helium from the fusion of hydrogen. This possibility had earlier been suggested by J. Perrin. When four nuclei of hydrogen combine to form one nucleus of helium, *some mass is lost*. Using the law of conservation of matter and energy via the celebrated Einstein equation $E = Mc^2$, Eddington argued that the mass loss would be compensated by energy which is what the star radiates.

There was one snag, however. The science of nuclear physics was in a very primitive state in the 1920s. The atomic physicists felt that Eddington's ideas will not work. For, the hydrogen nuclei are positively charged and any two of them would repel each other. Unless the nuclei are hurtled towards each other very fast they would not fuse together. Now, in a hot gas the nuclei do move very fast. But, according to the atomic physicists, at the temperatures of the order of ten million degrees or more that Eddington was talking about, the speeds of these nuclei would not be high enough for the fusion process to work.

Eddington was, however, confident that he was right. In his book *The Internal Constitution of the Stars*, he wrote:

......We do not argue with the critic who urges that the stars are not hot enough for this process. We tell him to go and find a hotter place...

A decade later Eddington was proved right. By mid-1930s, the science of nuclear physics had advanced to a stage where scientists had become better acquainted with the force of nuclear binding. In 1939, Hans Bethe used the ides of nuclear fusion of hydrogen to helium to generate realistic models of the Sun and stars.

Here we have another example, where astronomy has shown the way to basic science. I should mention that the fusion that operates in the Sun is the same thermonuclear process that operates in a hydrogen bomb, a process that was tested at Pokhran on 11 May 1998 by our scientists. The only difference is that the process operates in the Sun in a controlled fashion, whereas it does so in an explosive fashion in a bomb.

This brings me to the last question in the present context. Can we carry out this process in a controlled fashion on Earth? That the process can operate in a controlled fashion in the Sun has been demonstrated over the last five billion years or so. The challenge now lies in repeating on Earth what has been demonstrated in an astronomical setting.

It is easy for the Sun to do this because of its strong gravity. In a terrestrial experiment the controlling agency cannot be gravity (which is very weak on Earth). The present attempts revolve round containing hot plasma under a magnetic force. If the process succeeds, it may provide cheap ways of generating energy: for the fuel in the form of heavy water would be available from the seas around us.

Relationship to fundamental physics

The examples cited so far also demonstrate an important fact; namely the contributions astronomy makes to fundamental physics. The law of gravitation and controlled thermonuclear fusion came to physics via astronomy. Indeed the universe is a grand laboratory for science, with dimensions far exceeding that of any terrestrial laboratory. The laws of science that were first discovered and tested on Earth also receive a more severe testing in the cosmic laboratory. A few examples will suffice by way of demonstration:

- The cosmic radio sources emit energies of the order of 10^{60} ergs or more, that is about a hundred billion billion billion billion times the energy released in a one-megaton H-bomb.

- The rapidly pulsating radio sources called pulsars send signals with such regularity over periods as short as a few milliseconds that they more than match in stability and accuracy the best man-made atomic clocks.
- The highest-energy cosmic rays showering the Earth contain particles with energies a billion times that produced in the most advanced accelerator on Earth.
- Neutron stars contain matter with a density as high as a million billion times the density of water, far exceeding any density of a macroscopic form of terrestrial matter.
- The large-scale structure of the universe as revealed through the best telescopes of today extends out to distances which a light ray would take ten billion years to traverse. For a comparison, light takes only a second and a quarter to come here from the Moon.

Several more such examples can be given. What do they indicate? That the physicist is looking to astronomy to provide confirmation that the laws of physics discovered *here and now* are or were applicable *there and then*.

A very daring extrapolation of this idea appears in the studies of the very early universe. As per the popular belief (which I myself don't subscribe to!), the universe originated in a *hot big bang*, which took place some ten billion years ago. If we go right to the big bang instant, it supposedly lies beyond the scope of physics; because it describes a situation when physical quantities like density, temperature, etc., were infinite, when all mathematical operations broke down. However, the physicist's clock begins to tick immediately after this *singular epoch*. For example, as time elapses the universe cools down and its temperature drops.

We have already seen that the temperature of a gas is indicative of its dynamical activity. The higher the temperature, the higher is the energy of the typical particle of the gas. In the very early stages after the big bang, therefore, the particle energies were extremely high. This circumstance excited the high-energy particle physicists into using the very early universe as a testing space for their theories of unification.

I should state that the goal of unification of all basic interactions was first conceived by Albert Einstein who tried to look for a *unified field theory* of gravitational and electromagnetic interaction. His goal was to seek a description wherein the apparently separate phenomena of gravity and electricity and magnetism are seen as different manifestations of the same basic law of nature. His efforts were inconclusive and failed to excite the community of theoretical physicists. Wrote Wolfgang Pauli: *Let no man put together that God has put asunder.*

However, fashions change in science as they change in the world of dress designers! A few decades later physicists began to search for a unified framework that included not only the two phenomena Einstein was seeking to unite but also the other basic interactions (the so-called *strong and weak interactions*) that operate in the microworld of atomic nuclei and subatomic particles. A partial success in this direction was achieved when Abdus Salam and Stephen Weinberg produced a successful theory unifying the electromagnetic theory with the weak interaction; successful, because its predictions were verified in the powerful particle accelerator at CERN, near Geneva.

However, the next rung on the unification step-ladder is far steeper. For the so-called *Grand Unified Theory* (GUT in brief), the currently accepted standard model requires energies a *thousand billion* times what are achievable in the present accelerators. By 1980, the particle physicists had reached a stage where their theory could not be tested experimentally. And in science, a theory that cannot be tested is no more than a speculation.

It was against this background that the big bang cosmology offered a way out to the particle theorists. As we just saw, in the early epochs the typical constituent particles of the universe were indeed highly energetic and so could serve as the targets for testing the GUT predictions. Of course, for reaching the desired energies the epochs would have to be very early. *How early*? Calculations suggest that barely a *billion-billion-billion-billionth part of a second* had elapsed for the universe to have particles of the requisite energy! In other words, the particle theorists have in the universe itself a high-energy particle accelerator, which for a fleeting moment produced particles of high enough energy for testing their theories.

The advent of particle theorists into cosmology was also welcomed by the supporters of the big bang theory, as it provided 'physics' to discuss the behaviour of matter and radiation in the early epochs. For, cosmologists also have an agenda which includes a theory that explains the formation of large scale structure in the universe from the 'seeds' planted in the early epochs. The hope is that particle theories will tell us what those seeds could have been.

Sheldon Glashow has expressed this cosmology-particle physics interaction through the mythical snake (which also reminds us of our *Shesha Naga*) swallowing its own tail. The head of the snake has the whole universe and the tail the smallest particles; the act of swallowing symbolises a synthesis of the largest and the smallest.

Perhaps a note of caution needs to be interjected in all this excitement of understanding both the largest and the smallest in a joint effort. What we have here are two speculations, one from particle physics, viz., a GUT, the other from cosmology, the Big Bang. Two speculations may not make up certainty; at best they may be fitted into a self-consistent scenario. Nor is the scenario a repeatable experiment. For, as we saw, the universe passes through the GUT-phase only very fleetingly and the same conditions are not repeated later. Thus the standard scientific criterion of testing a theory through repeatable experiments is not met.

Nevertheless this example demonstrates how astronomy is proving indispensable to physicists.

Protection from collisions

I next come down to a more down to Earth issue which has recently shown how astronomy may become relevant to our very survival on this planet.

We are aware of the history of Jurassic age when huge beasts like dinosaurs used to dominate this planet. What happened to them? What catastrophe took place that wiped them entirely from the face of the Earth?

Speculations are many. But one possibility that is taken very seriously is that the Earth may have been hit by an extra-terrestrial body of appreciable mass and the impact caused a huge turmoil wiping out all, or at least most life forms from Earth. What could such a body be?

Judged by the crowded streets in a metropolis, the space in which the Earth moves is remarkably empty. The chance of a collision is very very small. But it is not zero. Let us see a few examples.

The surface of the Moon is pock-marked with craters, showing evidence that outside bodies have hit it on several occasions. The Earth has also such craters; only many of them are filled with water and appear as lakes. Some impact craters are confused with volcanic ones. Two examples of craters believed to have arisen from impacts are the Meteor Crater in Arizona, USA and the Lonar Crater Lake in the Buldhana district of Maharashtra in India. As the name of the first one suggests, the impacting body in both cases was a huge meteorite.

Meteorites are bodies orbiting within the Solar System, being relatively small bits that did not form into a (much bigger) unit like a planet. Some of them can come close enough to Earth to be attracted by its gravity. In that case, they 'fall' on Earth. Smaller bits of a few centimetres or less are usually burnt out by friction as they pass through the atmosphere. They are mistakenly called *'shooting stars'* or *'falling stars'*. Some do land on Earth and if noticed and collected, they end up as museum pieces and useful tools for geophysicists. Meteorites have been extremely useful in dating and estimating the age of the Solar System, as well as for getting information on its chemical abundances.

However, larger meteorites can be devastating in their impact. For example, the meteorite whose impact caused the 'hole' at Lonar was about 60 metres in diameter, weighing about twenty million tons. The impact caused a hole that today has a diameter of around 1,830 metres and a depth of 150 metres. The energy released in the process was equivalent to that coming from a 6-megaton H-bomb. For a comparison, the atom bomb dropped on Hiroshima was of 13 kiloton capacity, about two percent of the strength of the impact on Lonar. We will take the Hiroshima case as a unit of energy released.

There are bigger entities than such meteorites going around in the Solar System. In July 1994 Comet Shoemaker Levy had impacted on Jupiter. The event was witnessed by telescopes on Earth. On the huge planet the impact of a comet had, of course a transient and relatively mild effect. But what if a comet strikes the Earth? Indeed, such a possibility was raised in 1992 in connection with Comet Swift Tuttle. This comet passed by in 1992. At the time it was predicted that in its next visit on 14 August 2126, it will come very close to Earth. Although it cannot be definitely calculated, the probability of its actually hitting the Earth is not negligible. A better estimate can only be made when the comet is sighted again in 22nd century.

In the 1970s I had written a science fiction story in which a comet like this was headed for a collision with Earth. How did the scientists avert the catastrophe? The solution used in the story involved sending an unmanned spacecraft to rendezvous with the comet; with the provision that close to the comet it would carry out a nuclear explosion generating shock waves that would divert the comet from its original path. The same solution is now proposed for saving the Earth from an impending impact by a comet or a meteorite, or, what is now considered more of a threat, an asteroid.

Asteroids form a swarm of bodies moving generally in a belt between Mars and Jupiter. It is believed that these represent a 'failed planet', that is, a planet that did not form! These bodies are thus smaller than a planet like the Earth, ranging in sizes from several hundred metres to around 10 kilometres, although a few of them are larger, even up to 1,000 km in size. These bodies generally lie beyond Mars, although a few of them may occasionally come close to the Earth, thus raising the spectre of an impact. It is estimated that the number of asteroids of up to 1-km size may be between 1,000-2,000, while the number of 100-metre size objects may be as large as 1,00,000. Although the impact of a smaller object is less severe, the chance of its taking place is much larger.

How severe is the impact? The Lonar example gives some indication. However, suppose a 10-km size object hits the Earth, what will be the energy released? The answer is a staggering *'One billion Hiroshima's*. Not only will the area hit by the object devastated, the overall changes in the Earth's atmosphere will be such as to make life elsewhere on the planet impossible to sustain.

Keeping such possibilities in view, astronomers in the USA have initiated a *Spacewatch programme*, in which a dedicated 1.8-metre telescope is looking for all asteroids of such appreciable sizes in our neighbourhood. With their trajectories charted out we can predict if any of them will come dangerously close to Earth in the future, and take preventive action as needed.

This example again tells us that sky-gazing is not a mere idle activity; it can contribute to human survival.

Are we alone in the universe?

My last example in the list of challenges and benefits points to the future, to perhaps the most exciting discovery in the annals of human history. Who knows, but the present century may bring a positive answer to the frequently asked question: *Are we alone in the universe?*

If it does, a major contribution to the quest will have come from astronomy. In fact it is an inter-disciplinary issue but by and large it is the recent developments in astronomy that attracted scientists of several disciplines towards it. We may briefly mention the following highlights:

- The large-scale structure of the universe shows that our location on a planet around a star is very ordinary and there can be a large number of similar habitats available for hosting life.
- Millimetre-wave astronomy has revealed several giant molecular clouds containing chemical molecules of considerable complexity, including the kind of organic molecules we are made of.
- The evidence of fossilised life in the tiny Alan Hill Meteorite from Mars, although still very tentative, has raised the question whether life exists or existed on our neighbouring planet.
- The techniques of communication using the 21-centimetre wave band have reached the level of sophistication which makes interstellar communication possible. This is the natural frequency of neutral hydrogen, the most prevalent element in the Galaxy, and one likely to be best known to extraterrestrials.
- Advances in space technology may make it possible in future to set up a huge antenna in space for interstellar communication.

I have not mentioned the usage of space-ships, most popular with science fiction writers, for the simple reason that the distances in the Galaxy are so vast that use of space technology currently available to us makes it an impractical proposition. Their speed is so slow that using our present space ships to travel to the nearest star Proxima Centauri is worse than the case of an ant going from Chennai to Delhi!

Experts agree that the best way of looking for extraterrestrials is through radio signals using wavelengths like that of neutral hydrogen. These waves are less attenuated and are likely to be recognised by the recipients who should have gone through an evolutionary development which makes them with the sciences as we know them. Indeed they may, hopefully, be far more advanced than us, which will make it exciting for our scientists. Perhaps they can receive ready answers to their present puzzles and thereby make sudden leaps of progress!

However, patience is needed; for if we send a query to an extraterrestrial located at a modest distance of, say, ten light-years, our signal will take ten years to reach them and their reply another ten years, making it a twenty-year gap between question and answer. Still the effort would be worth it!

I hope that I have succeeded in a modest way in convincing you why it is so exciting and worthwhile to work in the science of astronomy.

Prof. Jayant Vishnu Narlikar is an eminent theoretical astrophysicist and winner of the Kalinga Prize for science popularization. He is a former Director of Inter-University Centre for Astronomy and Astrophysics, Pune

Letters to the Editor

A magazine of excellence

Being a regular reader of *DREAM 2047*, I find something missing when I do not receive it in time. The editorial in your March 2009 on 'Preserving Astronomical Heritage' was fantastic. Information about Hipparchus of Rhodes was interesting. Jayant V Narlikar's article on Scientific Temper, in contrast with traditional outlook of our society, was very informative. 'Green Revolution in Bioscience' by Biman Basu informs us about the field. The article on tobacco smoking by Dr. Yatish Agarwal was quite interesting. As a whole, every issue of *DREAM 2047* leaves an everlasting effect on the minds of its readers.

B.J. Trivedi, T.G.T. (E),
J.N.V. Orai, Disstt-Jalaun (UP)

Scientific temper

The article on the scientific temper by J V Narlikar in *DREAM 2047* (March 2009) is thought provoking. We are celebrating Galileo by observing 2009 as International Year of Astronomy. It is the time for the UGC to correct its mistakes in connection with astrology.

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Impressive editorial

I chanced to go through the January 2009 issue of *DREAM 2047* at my friend's place. The articles and the editorial are impressive and very informative indeed. Kudos to the entire editorial team! In the article 'Broken Symmetries' by Biman Basu there is a statement on p.28 which reads "...the 'strange' quark that would bind with an anti-up or an anti-down anti quark to form K-mesons". Actually, it is the strange anti-quark (and not strange quark) that binds with an up or a down quark to form K-mesons. I wish all the best to *DREAM 2047* in the New Year and the International Astronomy Year 2009.

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New Delhi-110070

Fuzzy Scare

Panic Disorder

> How does one kill fear, I wonder? How do you shoot a spectre through the heart, slash off its spectral head, take it by its spectral throat?
>
> Joseph Conrad *Lord Jim*

A panic attack can catch you off guard. A wave of fear, for no apparent reason, overwhelms you. Some two per cent of men and women suffer from this disorder, which recurs at its own will and terrorises the sufferer. You may choose to keep silent and suffer, or seek out one of the several treatment options. Simple medications to reduce anxiety can arrest the symptoms within one or two days, but a special brand of psychotherapy and relaxation techniques hold out the possibility of eliminating the illness altogether.

It can happen any time. Your inner self presses the panic button for no rhyme or reason. All of a sudden, an attack of terror and apprehension overwhelms you. Your heart begins to race, your face flushes, and you have trouble breathing. You feel dizzy, queasy, out of control—some people even feel they are going crazy or are about to die.

Every year, millions of people across the world go through an experience like this. Many, fearing the worst, think they're having a heart attack and rush to an emergency room. Others, though overtaken by fear, try to ignore it. But the story is much the same. Each of them just had a panic attack. Call it panic disorder, if you like.

Once dismissed as 'nerves' or stress, a panic attack is now recognised as a potentially disabling but treatable condition. Typically, the attack lasts from a few seconds to several hours. Most attacks, however, peak within ten minutes and exit within 20 or 30 minutes, leaving its sufferer sometimes with a vague sense of exhaustion. They may come back any time and the unpredictability regarding their reappearance perturbs the victim with persistent anxiety. Life is laden with fear and one simply does not know what to do. Some people feel so inundated with fear that they stop stepping out of their homes.

The disorder is fairly common. It affects about two per cent people during their lives and twice as many women as men. The attacks typically begin in young adulthood—late teens and early twenties—and can recur throughout life. While some people experience panic attacks frequently, almost daily or every week, others suffer the attack less often.

The condition tends to run in families; possibly heredity plays a role. If somebody has a diagnosed panic disorder, up to 18 per cent of his or her first-degree blood relatives may also suffer similarly. Studies done on identical twins also corroborate the genetic factor. If the disorder affects one of a pair of identical twins, the second twin runs a high risk of being similarly affected. But this kind of risk does not affect non-identical twins.

The hoax alarm

A panic attack clearly represents the activation of the body's natural alarm system, or the primitive fight-or-flight response to danger. For example, if an angry bull came after you, your body would react instinctively. Your heartbeat and breathing would speed up

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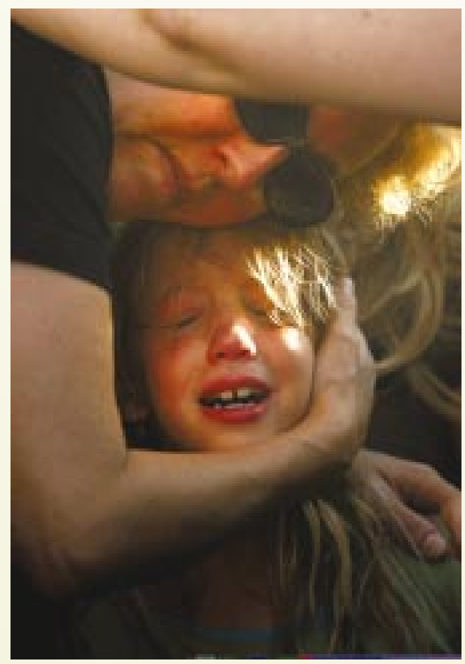
as your body readies itself for a life-threatening situation. Many of the same reactions occur in a panic attack. No obvious stressor is present but something triggers the body's alarm system. The fear of the attack is often so overwhelming that it begins to affect the quality of life and leads to curtailment of activity.

People with panic disorder may also run into other difficulties. They appear to have an increased risk of alcoholism and drug dependence. Some studies indicate they may also have a higher risk of depression and suicide.



Was it a Panic Attack?

Take a simple test

Do you think that you were hit by a panic attack? Did you press the fear button? Did you feel your body and mind went berserk for a few moments? If yes, take this test to know if you did have a panic attack.

Classically, a panic attack is a sudden, unexpected and overwhelming feeling of terror and apprehension, in which you find yourself overtaken by some strange symptoms. These symptoms develop abruptly and peak within 10 minutes. Tick the symptoms you remember had hit you:

1. You found your heart racing, pounding or throbbing with palpitations.
2. You were suddenly short of breath or felt as if you were being smothered.
3. You felt dizzy, unsteady, light headed, or faint.
4. You began to tremble or shake.
5. You found sweat suddenly pouring all over you.
6. You had a feeling of choking.
7. You experienced sudden chest pain or discomfort.
8. You had a nauseous feeling or tummy distress.
9. You felt a sudden numbness or tingling sensation.
10. You felt hot flashes or chills all over your body.
11. You had a feeling of unreality or being detached from the self.
12. You had a fear of going crazy or doing something uncontrolled.
13. You experienced sudden fear that you would die.

The result

If you tick off four or more of the above, you have a problem. Seek help.

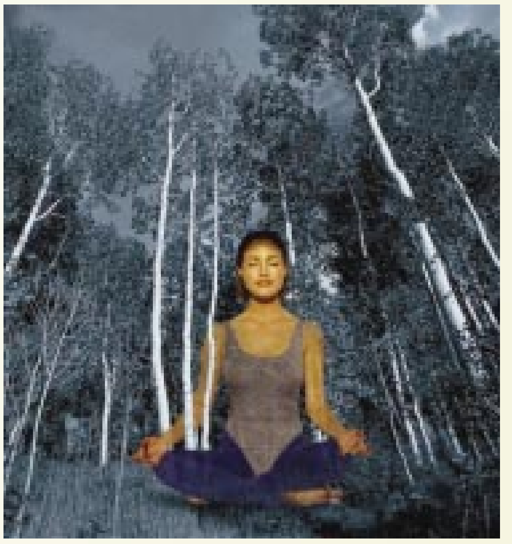
What causes panic disorder?

The current thinking regarding the origin of panic disorders is that they result from the interplay of multiple biological and psychological factors. The main contributory factor may be some genetic vulnerability, leading to a biological illness. Over time, panic attacks may also get associated with some environmental events that evoke stress and anxiety. The constellation of such stimuli could be an outcome of the past experiences or a psychological conflict. These particular conflicts arise from suppressed painful thoughts, impulses, or desires, either from the past or present. Sometimes no cause may be present at all, and the body just seems to react to stress. As such, the panic response is seen as an attempt to mobilise inner resources and ward off danger to the self. Some psychologists also believe that an early childhood experience of separation from important people, such as parents, increases the risk of panic disorder.

Treatment

Effective treatment for panic disorder is available. Most people are able to overcome the disorder with the help of medication, specialised psychotherapy, or a combination of both. The first step is to block the attacks with the help of medication. There are several options,

but the anxiolytics (anxiety reducing medicines), particularly alprazolam make a good choice. Taken in high doses, the medication benefits quickly, and provides relief within a day or two. It has few physical side effects, but it can be highly addictive and can impair mental ability in the long run, leading



to deficient concentration and loss of memory.

Antidepressant medications are another good option. They eliminate panic symptoms and provide relief in 80 to 90 per cent cases. The tricyclic antidepressants, amitryptline and clomipramine work well, but must be taken for at least four to six weeks. They also may cause side effects such as a dry mouth, constipation, blurring of vision, dizziness and drowsiness. The selective serotonin re-uptake inhibitors (SSRIs), including paroxetine and fluvoxamine, usually have fewer side effects and are quite effective. The biggest difficulty, however, with any medication is the high rate of relapse once a person stops using the medication.

Psychotherapy, particularly cognitive-behavioural therapy, helps control panic attacks. Under this method, therapists help people reconstruct the physical symptoms of the panic attack and teach them to think rationally about the situation. Most people feel better with just eight to ten sessions.

Physical relaxation techniques, such as deep breathing, yoga, and muscle relaxation also ease the stress and prove useful in developing a sound coping mechanism to control the panic attacks. ■

Recent Developments in Science and Technology

□ Biman Basu
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ISRO discovers bacteria in the stratosphere

The stratosphere is the third major layer of Earth's atmosphere, just above the troposphere, and ranges in height between about 10 km and 50 km. The temperature here rises with altitude – from about -100°C at the bottom to -3°C at the top. The heating is caused by an ozone layer that absorbs solar ultraviolet radiation, heating the upper layers of the stratosphere. With very high intensity of ultraviolet radiation from the Sun, the upper layers of the stratosphere constitute a hostile place for living organisms. But recently, three species of bacteria unknown on Earth have been found in stratospheric air in a unique balloon experiment conducted by Indian Space Research Organisation (ISRO). The three newly discovered species have been found to be highly resistant to ultraviolet radiation. One of the new species has been named *Janibacter hoylei*, after the distinguished astrophysicist Fred Hoyle; the second as *Bacillus isronensis*, recognising the contribution of ISRO in the balloon experiments which led to its discovery; and the third as *Bacillus aryabhata*, after India's celebrated ancient astronomer Aryabhata and also the first satellite of ISRO.

The ISRO balloon launch from the National Balloon Facility in Hyderabad.

The balloon experiment was a multi-institutional effort, with Jayant Narlikar from the Inter-University Centre for Astronomy and Astrophysics, Pune as Principal Investigator and veteran scientists U.R. Rao from ISRO and P.M. Bhargava from Anveshna as mentors.

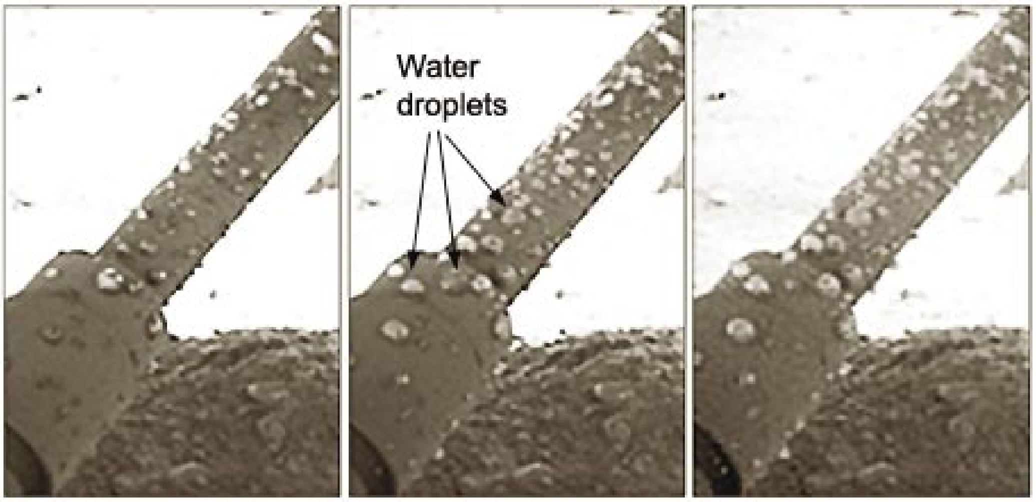
The experiment was conducted using a 7.5-lakh-cubic-metre balloon carrying a 459-kg scientific payload immersed in 38 kg of liquid neon at -246°C, which was flown from the National Balloon Facility in Hyderabad, operated by the Tata Institute of Fundamental Research (TIFR). The payload consisted of a cryosampler containing 16 evacuated and sterilised stainless steel probes. After collecting air samples from different heights ranging from 20 km to 41 km, the stainless steel probes were brought down by parachute and safely retrieved. The samples were then analysed by scientists at the Centre for Cellular and Molecular Biology (CCMB), Hyderabad as well as the National Centre for Cell Science (NCCS), Pune.

In all, 12 bacterial and six fungal species were detected, nine of which showed greater than 98% similarity with reported known species on Earth. According to ISRO sources, while the present study does not conclusively establish the extra-terrestrial origin of microorganisms, it does provide positive encouragement to continue the work in our quest to explore the origin of life.

Liquid water on Mars

Soon after NASA's *Phoenix Mars* lander touched down on the Red Planet in May last year, it sent back images of what looked like water ice (*Dream2047* July 2008). In February 2009, NASA scientists announced that the *Phoenix* may have found liquid water also. This astonishing claim is based on a series of black and white images, which appear to show droplets of water hanging off the lander's legs in the shade. According to the scientists, the water droplets were probably splashed from the Martian surface during *Phoenix*'s rocket-assisted landing. The interesting fact is that the water droplets appear to be growing, merging, and dripping on the lander's leg over the course of a Martian month.

But how can liquid water exist on Mars where the temperature ranges between -20 and -80°C even in the summer? The scientists have found an



Liquid water droplets seem to form and move on the leg of the Phoenix Mars *lander, as seen in images taken on days 8, 31, and 44 (left to right) of the craft's mission. Scientists think the water could stay liquid even in the frigid Martian surface because of its high concentration of perchlorates, salts that acts like antifreeze. (Image: NASA/JPL-Caltech//University of Arizona/Max Planck Institute)*

answer to this puzzle also, in the form of salts known as perchlorates. The discovery of perchlorates in the Martian soil was announced by the *Phoenix* team in August 2008, but at that time not much attention was given to its role in keeping water liquid.

As any chemistry student knows, dissolving salt in water reduces its freezing point. According to NASA scientists, if perchlorate is dissolved in significant quantities, water could remain as a liquid down to temperatures as low as -70°C. So it could be that the dissolved perchlorate salt is acting as an effective antifreeze to keep water liquid on Mars. The most likely candidates are magnesium and sodium perchlorates, based on the abundance of magnesium and sodium ions that *Phoenix* has detected.

According to Nilton Renno of Michigan University and *Phoenix* team member, the lander's thruster rockets would have melted the top millimetre of ice in the Martian surface while landing and the resulting water droplets may have been splashed onto the lander's leg. If the concentration of perchlorate in the soil was high enough, the water could have remained in a liquid state during the Martian daytime.

However, the presence of liquid water on Martian surface does in no way indicate the possibility of life on the Red Planet for the simple reason that perchlorates are highly toxic and are known to be a hindrance to life as we know it.

Neanderthal genome unravelled

Genome denotes the complete set of genes or genetic material present in a cell or organism. Every organism, including humans, has a genome that contains all of the biological information needed to build and maintain a living example of that organism. That is why there is worldwide interest in unravelling the genomes of different organisms, the latest success being the unravelling of the Neanderthal genome.

One of the biggest genome projects till now was the Human Genome Project (HGP), which was an international scientific research project with a primary goal to identify the over 3,000 million base pairs and to map the approximately 20,000-25,000 genes of the human genome from both a physical and functional standpoint. The project began in 1990 and a working draft of the genome was released in 2000. The complete human genome was published in 2003, with further analysis still being published.

Neanderthals were the closest relatives of currently living humans. They lived in Europe and parts of Asia until they became extinct about 30,000 years ago. For more than a hundred years, palaeontologists and anthropologists have been striving to uncover their evolutionary relationship to modern humans, who emerged roughly 400,000 years ago. Now researchers have revealed a first draft of the complete Neanderthal genome, a sequence of 3,000 million or so base pairs. Speaking at the annual meeting of the American Association for the Advancement of Science in Chicago on 12 February, Svante Pääbo, head of the project and director of genetics at the Max Planck Institute for Evolutionary Anthropology, in Leipzig, Germany, said that this first overview covers

Although the difference between the Neanderthal and human genome is only 0.5 per cent, the robust skeleton of a Neanderthal (left) is unmistakably different from that of a modern human (right). (Credit: G.J. Sawyer and Blaine Maley) about 63 percent of the Neanderthal genome. Most of it derived from just a half gram of bone removed from 38,000-year-old fossils excavated from Vindija Cave in Croatia.

The new gene map, which is the result of two and a half years' effort, suggests that humans and Neanderthals began to diverge genetically from a common ancestor about 800,000 years ago. The two populations co-existed but were genetically distinct by 300,000 years ago. The Neanderthal genome reveals that the difference between the genetic makeup of Neanderthals and modern humans differ by only 0.5 per cent, while in the case of chimpanzees, the difference is 1 per cent. Because Neanderthals were our closest relative during our evolutionary journey, differences between human and Neanderthal genetics could tell us what genes made us distinctly human.

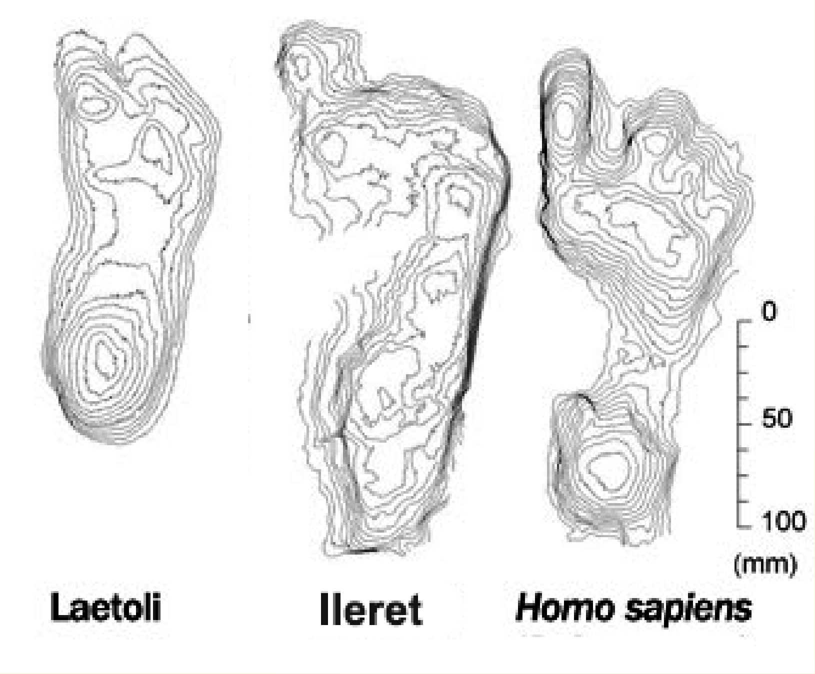
Despite its draft quality, the genome is already beginning to reveal a few of our ancestors' traits. For example, Neanderthals lacked the lactase gene, which allows adult humans to digest milk. But the researchers confirmed that the ancient hominid did share with us the only gene known to be implicated in speech and language, FoxP2. So, Neanderthals may have had the capacity to articulate as we do. However, the new data do little to further the idea that humans and Neanderthals interbred – something that has been the subject of much debate, but for which most experts agree there is little evidence.

Oldest human-like footprints

The earliest human ancestor to walk upright was *Australopithecus afarensis*, the oldest footprints of which, dating to 3.6 million years ago, had been discovered in 1978 by Mary Leakey at Laetoli, Tanzania. However, although the footprints indicated an upright posture, they showed a shallower arch and a more ape-like, divergent big toe – very different from the feet of modern humans. The oldest human-like footprints have been discovered recently by Matthew Bennett of Bournemouth University in Poole, England, and his colleagues at Ileret, Kenya, which is dated as 1.5 million years old (*Science*, 27 February 2009). The footprints, excavated between 2006 and 2008, have been identified as being of an early Africa-based *Homo erectus*, or *Homo ergaster* as some scientists call it. This was the first hominid to have had the same body proportions as our species, modern *Homo sapiens*.

The rare footprints at Ileret yielded valuable information about soft tissue form and structure not normally accessible in fossilised bones, and are the oldest evidence of essentially modern human-like foot anatomy. They provide new clues to the

1.5-million-year-old footprint discovered at Ileret, Kenya reveals short toes and a forward oriented big toe typical of modern humans. (Credit: M. Bennett/Bournemouth University)



Digital contour maps portray the shapes of footprints from Laetoli (left), Ileret (middle) and a British site inhabited by people around 3,000 years ago (right). (Credit: M. Bennett/Bournemouth University)

New Horizons

evolution of upright stance and walking in modern humans.

Measures of the size, spacing and depth of the Ileret footprints allowed the researchers to estimate the individuals' heights, weights and stride lengths, all of which fell within the range of modern humans. Digitized images of the newly discovered footprints show a big toe in line with the other toes, anatomically similar to modern human feet, an arrangement that contrasts with the angled, grasping big toes of apes. Other humanlike features of the prints include a pronounced arch and short toes. According to the scientists, spring-like arches and short toes observed in the Ileret footprints would have enabled endurance running, which was essential for the survival of the species as hunters/gatherers.

How sand dunes form

Sand dunes are prominent features of deserts that cover almost one-fifth of Earth's land mass. Giant sand dunes can gather into some of the most awe-inspiring patterns in nature and they constantly seem to be on the move. But the mechanics of their formation has long remained a mystery. Now a group of physicists based in Algeria, the US and France have come out with a hypothesis according to which the topology of these desert landscapes is governed by the thickness of the atmospheric layer above; a process similar to dunes forming on a river bed. After carrying out field measurements and aerodynamic calculations in the Algerian desert to model the interaction between the desert floor and the atmosphere they discovered that there exists a correlation between the separation of dunes and the height of the overlying atmospheric boundary layer – the part of the atmosphere that interacts directly with the Earth's surface (*Nature*, 26 February 2009).

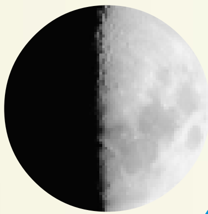
According to the researchers, the evenly spaced dunes along a river bed are in fact the result of rough bed topography. Inconsistencies in the river bed cause turbulence in the water; leading to formation of surface waves, which in turn stabilise the water flow along the river bed. The result is a controlled repetition of "waves" in the river silt where the wavelength is directly proportional to the depth of the river. Calculations reveal a similar process taking place in desert environments. Here, instead of a river surface, it is the atmospheric boundary layer that as a stabiliser for "waves" in the desert – the thicker the boundary layer the larger the distance between neighbouring giant dunes.

Comparing dune separation from deserts around the world with the overlying thickness of the atmospheric boundary layer, the researchers also could explain the range of mean spacing of dunes – from 300 m in coastal deserts to 3.5 km inland deserts. Also, contrary to previous theories, the researchers report that giant dunes do not grow in a steady manner but result from the non-linear interaction of small dunes.

Sand dunes are prominent features of deserts and cover almost one-fifth of Earth's land

Sky Map for May 2009

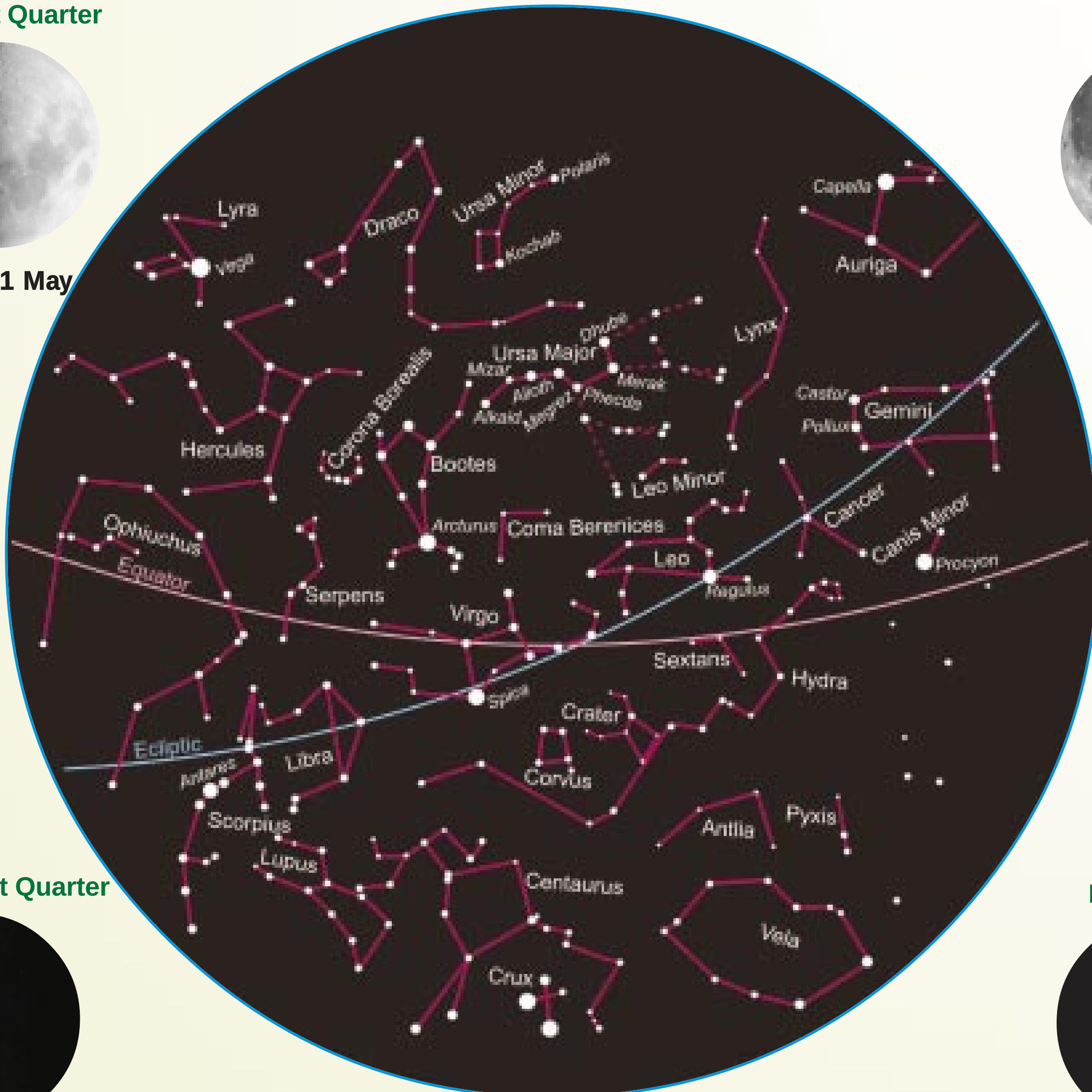
Moon - First Quarter



2 and 31 May

Full Moon

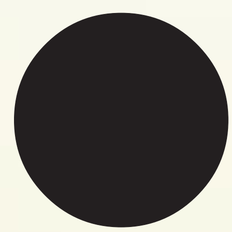
9 May



Moon - Last Quarter

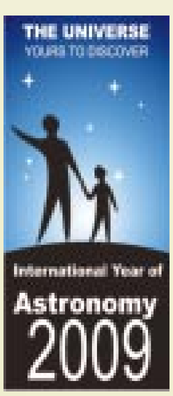
17 May

New Moon



24 May

The sky map is prepared for viewers in Nagpur (21.090 N, 79.090 E). It includes constellations and bright stars. For viewers south of Nagpur, constellations of the southern sky will appear higher up in the sky , and those of the northern sky will appear nearer the northen horizon. Similarly, for viewer 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 May, at 9 PM on 15 May and at 8 PM on 31 May.



Tips to use sky map:

(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 constellation as shown in the map one by one.

Visibility of Planets° (IST)

	Rising	Setting	In the Zodiac
Mercury	05:56	19:03	Taurus
Venus	03:14	15:30	Pisces
Mars	03:36	15:58	Pisces
Jupiter	00:54	12:14	Capricorns
Saturn	13:34	02:05	Leo
Uranus*	02:29	14:25	Pisces
Neptune*	00:56	12:18	Capricorns

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

Sky Event

Date	IST	Event
14	08:27	Moon at apogee
17	13:22	Moon-Jupiter
18	15:34	Mercury Inferior Conjunction
21	13:44	Moon-Venus
26	09:14	Moon at perigee

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Astronomy

Editorial (Contd. from page 43)

hypertext file) would link the user to another location or file. It is interesting to note that it was to click on the hyperlinks that the mouse was invented by Douglas Engelbart. The mouse was to later become a very important part of personal computers. The idea of clicking on a word or a picture to take a user somewhere else was a basic foundation of the Web.

Next came URL (Uniform Resource Locator), allowing one to find one's way around by naming a site. Yet another feature was the *Hypertext Markup Language* (html), the language that allowed pages to display different fonts and sizes, pictures, colours and so on. Before HTML, there was no such standard. The GUIs we talked about earlier only belonged to different computers or different computer software. They could not be networked. This was the situation that existed till 1989, when Tim Berners Lee brought this all together and created the World Wide Web (WWW or the Web). It may not be an exaggeration to say that the Web saved the Internet! Not only did it change appearance of the Internet, it made it possible for pictures and sound to be displayed and exchanged. How did it all happen?

The Web was, in fact, invented to deal with a specific problem. In the late 1980s, CERN was planning one of the most ambitious scientific projects ever, the Large Hadron Collider, or LHC. We may note that LHC was started, and then shut down again because of a leak in its cooling system, in September 2008. Tim Berners-Lee's proposal aimed at keeping track of the huge data LHC would generate, sharing it, and linking of electronic documents in laboratories around the world. The first few lines of the proposal read: "Many of the discussions of the future at CERN and the LHC era end with the question - 'Yes, but how will we ever keep track of such a large project?' This proposal provides an answer to such questions". The proposal incorporated three technologies - HTML, HTTP and a web browser client software program to receive and interpret data and display results. An important concept of his proposal included the fact that the client software program's user interface would be consistent across *all* types of computer platforms so that users could access information from many types of computers.

Tim Berners-Lee and his colleagues at CERN, such as Robert Cailliau came up with the first web browser in October 1990, which looked pretty similar to the ones used today. By 1991, browser and web server software was available, and by 1992 a few preliminary sites existed. By the end of 1992, there were about 26 sites. May 1991 was the first time that the information-sharing system using HTML, HTTP, and a client software program (WWW) was fully operational on the multiplatform computer network at the CERN laboratories in Switzerland. All of the documents coded with HTML elements were stored on one main computer at CERN called a "web server" because it "served-up" batches of cross-linked HTML documents. There was only one Web server located at CERN, but by the end of 1992 there were over 50 Web servers in the world, mainly used by thousands of scientists around the world to swap, view and comment on their research, regardless of the distance or computer system.

The Web, as we know, has found uses far beyond linking of electronic documents about particle physics in laboratories around the world. Cailliau still marvels at developments like wikipedia that allow knowledge to be exchanged openly around the Web. A search engine is very centralised, while the Web is totally decentralised. From personal and social networks, industry to commerce, it has transformed the business of doing science itself. This is why the number of WWW (Internet) users that was only a few thousand in 1992 - mostly scientists exchanging information in different parts of the world - swelled to 36 million from all walks of life in 2000. In 2008 it was 1.6 billion. In India, there are 60 million Internet users today as compared to about 4 million in 2003.

How has the Web changed the way we do science? We are familiar with the benefits of journals being published online and links to be made from one paper to another. It has also permitted professional scientists to recruit thousands of amateurs to help them in their research. In one such project, called GalaxyZoo, used this *unpaid* labour to classify 1 million images of galaxies into various types - spiral, elliptical and irregular. This project, intended to help astronomers understand how galaxies evolve, proved to be so successful that a new project now has been launched to classify the brightest quarter of a million of these galaxies in finer detail. There is also an ongoing project to scrutinise and decipher scanned images of handwritten notes about old plant cuttings stored in British museums. This could allow the tracking of changes in the distribution of species in response to, say, climate change. Scientists have thus been utilising the Web to further their research. There are also novel scientific applications of the web allowing social scientists to do things that would have been impossible previously, say in studying the phenomena like social networking.

What does Tim Berners-Lee think of the future of the Web? The next avatar of the Web would be one in which information is given well-defined meaning, better enabling computers and people to work in cooperation. In the near future, these developments will usher in significant new functionality as machines become much better able to process and *understand* the data that they merely display at present. Another key future development is the web-to-mobile initiative, he says. The Web is one of the many different applications which are run over the Internet. However, the achievement of Tim Berners-Lee was to recognise the power and potential of the Internet. Indeed, the Web is now the web of life!

Vinay B. Kamble

Vigyan Prasar Digital Library

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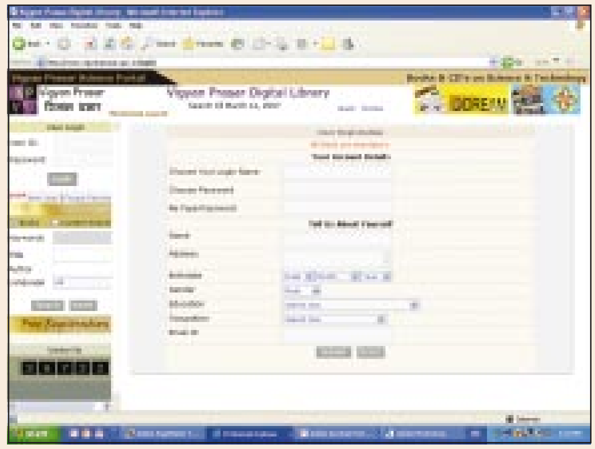

YOUR OPINION

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

This month's topic:

Do you consider beliefs in astrology, palmistry, feng shui, etc., as obstacles to development of scientific temper?

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

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

Winners of "Your Opinion" contest for January 2009.

Topic: India plans to send a manned mission to space in near future. How in your opinion will this mission benefit Indian science and technology?

1. W. Yaiskul Singh
   Senior physics teacher,
   Modern English H.S. School,
   Aizawl -796001 (Mizoram)
   E-mail: yaiskuls@yahoo.com

"Considering India's economic problems, slums and billon-plus population, widespread poverty, rampant illiteracy, and deep-rooted traditional beliefs, communalism and irrationalism needs to be stamped out. Fallacious beliefs in irrational thought have to be eradicated. Cutting edge space research needs to be funded and pursued with more vigour. Wasteful expenditure and corruption needs to be rooted out from all section of the society".

2. Faiyaz Nazar
   C/o Rajjab Umar
   Qabrastan Gate, Mominpura,
   Nagpur-440018 (Maharashtra)

"The mission is perfectly in tune with excellence demonstrated by ISRO that it goes to next step with significant strides in space science and technology. The manned mission to space by India will begin new era in India science and technology and promise to occupy a place in journey for exploring the universe. Every journey starts with small steps and it is hoped that the endeavor would enable us to take giant leap forward in exploring the universe. This would help us to go from engineering science to big science".

The winners will receive a copy of VP Publication

Development of Resource Material for Science Writing Training Workshops

Vigyan Prasar has been organising seminars/workshops for promoting science writing in Hindi as per the directives of Union Rajbhasha Directorate. As part of this activity Vigyan Prasar jointly with Vigyan Parishad Prayag, Allahabad organised a workshop at Allahabad during 8-9 March 2009. The theme of the workshop was development of resource material for training young science writers in Hindi.

Prof. Krishna Bihari Pandey inaugurating the workshop. Sitting (L to R) Prof. S.G. Misra, Prof. K. K. Bhutani, Dr. Subodh Mahanti and Air Vice Marshal (Retd.) Vishwa Mohan Tiwari

A section of the audience

In his inaugural speech, the chief guest, former chairman of Uttar Pradesh Public Service Commission Prof. Krishna Bihari Pandey said that science writers should keep in mind the welfare of the people. They should promote a constructive thinking and empower people to improve their quality of life. Prof. K. K. Bhutani, Vice President, Vigyan Parishad Prayag, presided over the session on useful resource materials for science writer. Vice Marshal (Retd.) Vishwa Mohan Tiwari said that science writers should keep in mind that the ultimate aim of science should be betterment of humankind. Dr. Subodh Mahanti, Scientist 'F', and Chairman, Rajbhasha Karysamiti, Vigyan Prasar briefly described the activities of Vigyan Prasar with special emphasis on its efforts in promoting science communication in Hindi.

The workshop was divided in four technical sessions. The following experts presented papers : Dr. C.M. Nautiyal, Prof. Krishna Mishra, Dr. Pradeep Mukharjee, Sri Kali Shankar, Sri Hari Shankar Deiwedi, Dr. Puneet Kumar, Dr. Rajendra Prasad Mishra, Sri Subhash Lakheda, Sri Radhakant Anthwal, Sri Lalit ishore Pandey, Sri Harish Goyal, Shri Premchandra Srivastava, Sri Shananjay Chopra, Sri Vijay Chitouri, Sri Devvrat Diwadi.

Shri Nimish Kapoor and Sri Kapil Tripathi, Scientist, VP coordinated the technical sessions.

At the valedictory function, the known litterateur Shri Prem Pal Sharma (Joint Secretary, Railway Board) was present as chief guest. Shri Sharma said our media need better scientific thinking and attitude and journalists must avoid rumours on science and health issues. He said science writers must fight superstitions and science popularisation is required among school children as well as masses. The chairman of the session, Prof. Shiv Gopal Misra said efforts would be made to train writers and journalists in science writing. On this occasion Dr. Subodh Mahanti said that workshop is a successful attempt on resource material development for science writing workshops, but these efforts need to be continued. He said principles need to be established for science writing and this is a need of time to train our young writers and journalist about the 5 Ws and 1 H of science writing. ■