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The Golden Ratio

The World's Most Astonishing Number

Harish-Chandra

(1923-1983)

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

On mathematics

Dr. Subodh Mahanti

The word "mathematics" is derived from the Greek word "*mathema*", which encompasses knowledge, study and learning. The origins of mathematics can be traced to antiquity. Prehistoric human beings probably learned to count at least up to ten on their fingers. Ancient Indians, Chinese, Babylonians, and Egyptians devised methods of counting and measuring that were of practical importance in their everyday lives. With the passage of time surveyors, clock and calendar makers, masons and machine makers, and most importantly merchants and machine makers, developed the methods of counting and measuring. Mathematics is the science of spatial and numerical relationships or the logical study of numerical and spatial relationships. It is usually divided into pure and applied mathematics. The main divisions of pure mathematics are: geometry, arithmetic, algebra, calculus, and trigonometry. Mechanics, statistics, numerical analysis, computing, the mechanical theories of astronomy, electricity, optics, thermodynamics, and atomic sciences come under the heading of applied mathematics. Today mathematics is used almost in every sphere of natural science. And so we see the emergence of disciplines like mathematical biology, mathematical ecology, mathematical geography, mathematical physics, and so on.

Mathematics is usually not regarded as a branch of natural science. It is said that one can practice meaningful mathematics without being concerned with natural science and so it is no wonder that mathematics is often viewed as a realm of knowledge entirely unto itself. It is construction of pure logical thought. However, on reflecting at a deeper level one can realise that mathematics is the language of science. Mathematics has evolved to be an indispensable medium 'by which and within which science expresses, formulates, continues, and communicates itself.' Roger Bacon (1214-1292) was right when he wrote in his Opus Major (1266) that "Mathematics is the door to the sciences." Mathematics specifies, clarifies and makes rigorously workable concepts and laws of science. Mathematics becomes an important means in creating new scientific concepts.

India has a rich mathematical heritage. India's greatest contribution to mathematics is the number 'zero' and the decimal place value system, which established the modern way of writing numbers. The Vedic literature—the *Samhitas*, the *Kalpasutras* and the *Vedangas*—give an idea of ancient India's mathematical ability during the time of its development. The *Sulba-sutras* (*Baudhayana Sulba-sutra*, *Manava Sulba-sutra*, *Apastamba Sulba-sutra*, and *Katyana Sulba-sutra* being the most important ones) contain information concerning arithmetical operations, fractions, properties of rectilinear figures, irrational numbers, quadratic and indeterminate equations and other related matter. The *Siddhant* (or mathematical astronomy) tradition starting with Aryabhata (476-550) and going beyond Bhaskara II (1114-1185) showed the continuation of mathematical tradition in India. Some of the important works describing development in this period are *Aryabhatiya*, *Brahmasphutasiddhanta*, *Lilavati*, and *Bijaganita*. The Jain tradition (from the 8th century till the middle of the 14th century) demonstrated considerable mathematical activity. *Ganitasarasangraha* of Mahavira (850) is a very influential work on mathematics. The Kerala school of mathematics, which originated with Madhava in the late 14th century and continued well into the 17th century, developed mathematics at much advanced level compared to earlier works from anywhere in the world. Ancient Indian mathematicians showed great fascination for large numbers.

Geometry started taking roots in India in the first millennium BC. The *Sulba-sutra* geometers were familiar among many other concepts of geometry, of what is now called the Pythagoras theorem about 200 years before Pythagoras. Arithmetic and algebra were pursued with great success. There was a time when India was ahead in mathematics than any part of the world. In modern time the emergence of Srinivasa Ramanujan will remain as major hallmark in the history of development of mathematical ideas.

Western mathematics began to grow from the 15th century. The Scientific Revolution gave mathematical ways of knowing about the physical world a new status. It became clearer that mathematics could provide knowledge of the world that could be sure and certain without engaging in the argumentation of the natural philosophers and not just mystical and symbolic. Some noted natural philosophers, viz., Galileo Galilei, Rene Descartes, Christiaan Huygens, and Isaac Newton aimed at bringing their discipline under the sway of mathematics. Algebra, the mathematics of equations, the origins of which could be traced to ancient India, became a clear object

Continued on page 27

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Harish-Chandra

The Greatest Indian mathematician since Srinivasa Ramanujan

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"I have often pondered over the roles of knowledge or experience on the one hand, and imagination or intuition, on the other, in the process of discovery. I believe that there is a certain fundamental conflict between the two and knowledge, by advocating caution, tends to inhibit the flight of imagination. Therefore a certain naivete, unburdened by conventional wisdom, can sometimes be a positive asset. I regard Dirac's discovery of relativistic equation of the electron as a shining example of such a case."

Harish-Chandra in a talk given on the occasion of the 80th birthday celebration for Dirac (quoted from 'Harish-Chandra' by R. Tandon, *Resonance*, August 1996)

"It is difficult to communicate the grandeur of Harish Chandra's achievements…The theory he created still stands — if I may be excused a clumsy simile — like a Gothic cathedral, heavily buttressed below but, in spite of its great weight, light and soaring in its upper reaches, coming as close to heaven as mathematics can. Harish who was of a spiritual, even religious, cast and who liked to express himself in metaphors, vivid and compelling, did see, I believe, mathematics as mediating between man and what one can only call God. Occasionally, on a stroll after a seminar, usually towards evening, he would express his feelings, his fine hands slightly upraised, his eyes intent on the distant sky; but he saw as his task not to bring men closer to God but God closer to men. For those who can understand his work and who accept God has a mathematical side, he accomplished it."

R. P. Langlands in *Harish-Chandra: In Memoriam*, Princeton, 23 April 1984

Harish-Chandra is regarded as the greatest Indian mathematician since Srinivasa Ramanujan, who rose to become a mathematician of world stature. He is rightly regarded as one of the greatest mathematicians of his era. It should be noted at the beginning that Harish-Chandra's contribution lie in the realm of higher mathematics and to appreciate the true signification of his work one should have an appropriate background in mathematics. But then even those including the author of this article, who are not in a position to understand the actual work, will certainly be by inspired Harish-Chandra's life and work. In this context it is pertinent to quote N. Mukunda from what he wrote in his editorial in *Resonance* while commenting on Harish-Chandra: "To very few of us is it given to be able to even appreciate the work of such gifted individuals, leave alone to reach such heights ourselves. And yet all we need heroes — verily the salt of the earth — from whom to derive the inspiration to reach beyond ourselves."

The present article does not aim to elaborate on the actual work of Harish-Chandra but to give some glimpses of his life and the scope of his work and in doing so the author has chosen to truly quote those who are competent to comment on the life and work of Harish-Chandra.

Harish-Chandra is best known for his general theory of semi-simple Lie groups. He formulated a fundamental theory of representations of Lie groups and Lie algebra. He started his work on Lie groups in 1949 and went on to erect his monumental theory over the course of three decades or so. The depth and beauty of his work it one of the most profound of twentieth century mathematics. And what is important is that he did it single-handedly. He published only one joint paper with A. Borel. He also extended the concept of a characteristic representation of finite-dimensional of semi-simple Lie groups to infinite-dimensional representations of a case and formulated a Weyl's character formula analogue. His other major contributions included: the construction of the Plancherel measure of semi-simple Lie groups; the evaluation of the representations of discrete series; his results on Eisenstein series; the theory of automorphic forms; his philosophy of cusp forms as a guiding principle to have a common view of certain phenomena in the representation theory of reductive groups in a rather broad sense. In the words of R. P. Langlands: "Harish-Chandra was one of the outstanding mathematicians of his generation – an algebraist and analyst, and one of those responsible for transforming infinite-dimensional group representation theory from a modest topic on the periphery of mathematics and physics into a major field central to contemporary mathematics." His work is a synthesis of analysis, algebra and geometry is of lasting influence. Roger Howe wrote: "Harish-Chandra was, if not the exclusive architect, certainly the chief engineer of harmonic analysis on semi-simple Lie groups. This subject, with roots deep in mathematical physics and analysis, is a synthesis of Fourier analysis, special functions and invariant theory, and it has become a basic tool in analytic number theory, via the theory of automorphic forms. It essentially did not exist before World War II, but in very large part because of the

Harish-Chandra

labours of Harish-Chandra, it became one of the major mathematical edifices of the second half of the twentieth century."

To get some idea about the philosophy of Harish-Chandra is life we quote Armand Borel: "Harish-Chandra was a highly principled man, for whom one's life had to have purpose. In his view, the main one of his own life was no doubt to prove the hardest and the most fundamental theorems accessible to him…Underlying this tremendous productivity were very strict, almost ascetic, disciplined and routine… The sense of purpose Harish gave to his life had some spiritual, even religious underpinning. His religion was not a traditional one with the usual paraphernalia of stories, rituals, prayers and direct intervention of a personal god. Rather it was an abstract, philosophical level, a yearning for some universe principle, transcending our lives, which would give sense to the universe."

C. V. Raman

Describing the personality and character of Harish-Chandra, J. D. Zund wrote: "…he was a tall, handsome man, who was somewhat reserved, but who possessed a formal courtesy that did not conceal the depth of his feelings and thought. In his early years he liked to paint and later expressed a fondness for the French impressionists… One of his colleagues suggested that Harish-Chandra survives in his work, which faithfully mirrored his personality: intense, lofty, and uncompromising."

Harish-Chandra spent most part of his professional career abroad but he remained an Indian by heart till the end of his life. His daughter Premala Chandra says: "Though he spent almost all of his professional life abroad, culturally my father was always very deeply rooted in India."

One may wonder about the hyphen in the name of Harish-Chandra because normally one does not come across hyphenated names. His original name was Harishchandra and the hyphen was bestowed on him by the copy editor of his first scientific papers. Harishchandra decided to adopt the hyphen.

Harish-Chandra was born on 11 October 1923 in an educated family Uttar Pradesh (then United Provinces) in northern India. His parents were Chandrakishore and Chandrarani (original name Satyagati Seth). Harish-Chandra had two brothers and one sister. His father, Chandrakishore, was an ardent follower of Mahatma Gandhi and had dropped his surname because of his opposition to the caste system. Chandrakishore was an irrigation engineer and in the early years of his career he spent most of his time in different districts of Uttar Pradesh. According to the *Biographical Memoirs of Fellows of the Royal Society*: "Harish-Chandra's father, a civil engineer, eventually rose quite high, reaching the middle echelons of the Indian Service of Engineers, and retiring as Executive Engineer of the Uttar Pradesh Irrigation Works; but his early career would have been spent in the field, usually on horseback, inspecting and maintaining the dikes of the extensive network of canals in the northern plains… Harish-Chandra, though not a robust child, often accompanied his father on his rounds, but it was until later, when he was a young man and his father retired, that they became close."

K. S. Krishnan

H. J. Bhabha

Harish-Chandra's childhood was spent in Kanpur in his maternal grandfather's home. His maternal grandfather Ram Sanethi Seth was a successful lawyer. Harish-Chandra's early education was at home by private tutors. At the age of nine he was sent to a school, Christ Church High School, where he was directly admitted to the class seven. After completing his high school education at the age of fourteen, he joined the BNSD Inter College at Kanpur and from where he went to the Allahabad University. He obtained his BSc (1941) and MSc (1945) degrees from Allahabad University. His initial desire was to devote his life to the study of theoretical physics. Harish-Chandra later recalled that his reading of Paul A. M. Dirac's *Principle of Quantum Mechanics* was mainly responsible for getting him attracted to theoretical physics. Harish-Chandra was particularly influenced by its lucid style and powerful ideas. At the Allahabad University he came in contact with K. S. Krishnan, the distinguished Indian physicist. C. V. Raman, the celebrated physicist of India was Harish-Chandra's MSc examiner. It may be noted that Raman was Krishnan's research supervisor in the Indian Association for the cultivation of Science in Kolkata (then Calcutta). It was Krishnan who persuaded Harish-Chandra to go to the Indian Institute of Science, Bangalore to work with H. J. Bhabha in theoretical physics. Harish-Chandra worked with Bhabha for about two years and published research papers on classical point-particles, their equations of motion and the fields associated with them. Because of these papers Harish-Chandra came in contact with P. A. M. Dirac, as they dealt with one of Dirac's research interests. He was recommended to Dirac for his doctoral work by Bhabha and Krishnan.

P. A. M. Dirac

In 1945, Harish-Chandra went to the Gonville and Caius College of the Cambridge University, Cambridge, United Kingdom, where he worked for his PhD degree under the supervision of Paul Dirac, one of the founders of quantum mechanics. He was awarded his PhD degree in 1947 for his thesis entitled "Infinite irreducible representations of the Lorentz group." Harish-Chandra found Dirac 'very gentle and kind and yet rather aloof and distant'. He did not have much personal interaction with Dirac because he had decided not to 'bother him too much'. Harish-Chandra later recalled that he went to see Dirac 'about once each term'. It has been reported that Harish-Chandra stopped attending Dirac's chasses after realising that Dirac was actually reading from one of his books. In spite of all this Harish- Chandra was greatly influenced by Dirac.

When Dirac visited the Institute of Advanced Study at Princeton, USA for a year (1947-48), Harish-Chandra accompanied him as his assistant. In Princeton Harish-Chandra could meet leading mathematicians

like Hermann Weyl (1885-1955), who gave the first rigorous account of the Riemann surfaces. Emil Artin (1898-1962), who solved David Hilbert's problem concerning the existence of a general reciprocity law and in this way he completed a line of inquiry begun by Carl Friedrich Gauss which was central to the theory of numbers, and Claude Chevalley (1909-1984), who made important contributions to number theory, algebraic geometry, finite group theory, and theory of algebraic groups. He was greatly influenced by these outstanding mathematicians. It was at Princeton that he decided that he should pursue mathematics and not physics. Harish-Chandra wrote: "Soon after coming to Princeton I became aware that my work on the Lorentz group was based on somewhat shaky arguments. I had naively manipulated unbounded operators without paying any attention to their domains of definition. I once complained to Dirac about the fact that my proofs were not rigorous and he replied, 'I am not interested in proofs but only in what nature does.' This remark confirmed my growing conviction that I did not have the mysterious sixth sense which one needs in order to succeed in physics and I soon decided to move over to mathematics." It is to be noted that there was no lengthy gap in his scientific output while making a transition from physics to mathematics. In fact his last physics papers were published in 1948 and his papers on mathematics started appearing in 1949.

Hermann Weyl

Emil Artin

Carl Friedrich Gauss

Claude Chevalley

R. P. Langlands has described how Harish-Chandra, being both a theoretical physicist and mathematician, viewed the relationship between physicist and mathematician in the following words: "Although he (Harish-Chandra) was convinced that the mathematician's very mode of thought prevented him from comprehending the essence of theoretical physics, where, he felt, deep intuition and not logic prevailed and skeptical of any mathematician who presumed to attempt to understand it, he was even more impatient with those mathematicians in whom a sympathy for theoretical physics was lacking, a failing he attributed in particular to the French school of the 1950s."

Dirac went back to Cambridge, UK, but Harish-Chandra remained in USA. After staying one more year at the Institute of Advanced Study, he moved to Harvard University for a year (1949-50). At Harvard he came in contact with Zariski. From Harvard he moved to Columbia University, where he stayed from 1950 to 1963. While staying on the faculty of the Columbia University, Harish-Chandra spent considerable periods in other institutions — Tata Institute of Fundamental Research, Mumbai (then Bombay, 1952-53); Institute of Advanced Study, Princeton (1955-56 and then again during 1961-1963 as Sloan Fellow); and Paris (1957-58) as Guggenheim Fellow. In 1963, he was made a permanent faculty of the Institute of Advanced Study, and where remained till his death.

Harish-Chandra was elected a Fellow of the Royal Society of London in 1973. He was also a Fellow of the National Academy of Sciences of the United States of America (1981), and Indian National Science Academy (1975). He was awarded honorary doctorate degrees by Delhi University (1973) and Yale University (1981). Among the awards received by Harish-Chandra were the Cole Prize of the American Mathematical Society (1954) and the Ramanujan Medal of the Indian National Science Academy (1974). The Harish-chandra Research Institute of Mathematical Sciences is named after Harish-Chandra. The institute is funded by the Department of Atomic Energy, Government of India and it is located in Jhusi, Allahabad.

Harish-Chandra died of heart attack on 16 October 1983, while on an evening walk during a conference in Princeton held in honour of Armand Borel's 60th birthday.

We would like to end this brief write-up by quoting V. S. Vardarajan: "In the austere simplicity and uncompromising nature of his approach to life, in his preference for solitary and profound reflection, and in his awesome capacity to discern and preserve after distant goals, he resembled the legendary figures from his country's ancient past. And like them, he came to be quite detached about his achievements as well as his failures. The detachment was not a false modesty; like many great men Harish-Chandra was fully conscious of his gifts and what he could do with them. It was rather a deeper humility, whose origin lay in a conviction that science was a collective endeavour and that any life is but a fragment in a larger fabric."

(The author is grateful to Shri Sanjay Kumar, Centre for Advancement of Public Understanding of Science and Technology (CAPUST), New Delhi for making him known the existing literature on the life and work of Harish-Chandra)

References

1. *Resonance*, August 1996 (this issue of Resonance contains an article by R. Tandon and two quotations of R. P. Langlands and V. S. Vardarajan on Harish-Chandra).
2. Vardarajan, V.S., Harish-Chandra (1923-1983), *The Mathematical Intelligencer*, Vol.6, No.3, pp.9-13 & 19, 1984.
3. Langlands, R. P., "Harish-Chandra", *Biographical Memoirs of Fellows of the Royal Society*, Vol.31, pp. 199-225, 1985.
4. Howe, Roger, "Harish-Chandra (1923-1983)", *Biographical Memoirs*, National Academy of Sciences, Washington, D.C., 2011.
5. www.gap-system.org/~history/Biographies?Harish-Chandra.html
6. O'Connor, J. J., and E. F. Robertson, "Harish-Chandra" http://en.wikipedia.org/wiki/Harish-Chandra

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

The Golden Ratio (Φ)

The World's Most Astonishing Number

"The mathematician does not study pure mathematics because it is useful; he studies it because he delights in it and he delights in it because it is beautiful."

Henri Poincaré (1854 – 1912), French mathematician and physicist.

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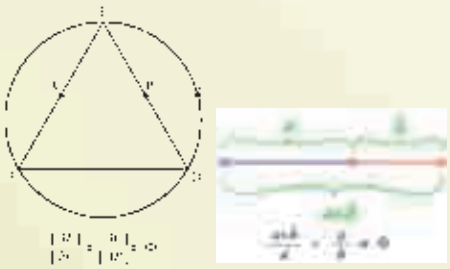
Throughout the history, thinkers from mathematicians to theologians have pondered over the mysterious relationship between numbers and the nature of reality. One of the mysterious relationships is Φ (phi = 1.6180339887...), and this curious mathematical relationship is widely known as the "golden ratio". It was discovered by Euclid more than two thousand years ago because of its crucial role in the construction of the pentagram. Since then it has shown a propensity to appear in the most astonishing variety of places, from mollusc shells, sunflower florets and rose petals to the shapes of galaxies. Golden ratio is one of the most beautiful ratios of the mathematical universe because of its elegance and simplicity.

What is golden ratio?



Golden ratio is defined as a line segment divided into two unequal parts, such that the ratio of the longer portion to the shorter portion is same as the ratio of the whole length to the longer portion. It is believed that this ratio is found throughout nature and is an integral part of art, architecture, music, philosophy, science, and mathematics.

The precise value of the golden ratio is a never ending and never repeating number 1.6180339887…., and such never ending numbers have intrigued humans since antiquity.

A variant of golden ratio is the golden rectangle, whose side lengths are in the golden ratio, or approximately 1:1.618. A distinctive feature of the golden rectangle is that when a square section is removed, the remainder is another golden rectangle; that is, with the same proportions as the first. Square removal can be repeated infinitely, in which case corresponding corners of the squares form an infinite sequence of points on the golden spiral, the unique logarithmic spiral with this property. Many artists and architects have been fascinated by the presumption that the golden rectangle is considered aesthetically pleasing.

Many artists and architects have proportioned their works to approximate the golden ratio—especially in the form of the golden rectangle, in which the ratio of the longer side to the shorter is the golden ratio—believing this proportion to be aesthetically pleasing. Mathematicians have studied the golden ratio because of its unique and interesting properties.

How to construct a golden rectangle

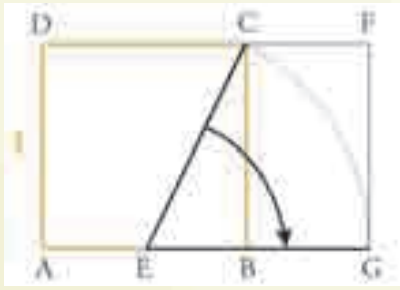


Figure 1

Construct a simple square of unit length (say AB = 1 inch, in figure 1). Draw a line from the midpoint (E) of one side (AB) of the square to an opposite corner (C). Use this line (EC) as the radius to draw an arc (EC=EG) as shown in figure 1. Complete the rectangle AGFD.

Now, BC = 1, EB = 1/2

Using Pythagoras theorem, $EC^2 = EB^2 + BC^2 = (1/2)^2 + (1)^2 = 1/4 + 1 = 5/4$

Therefore $EC = \sqrt{5}/2 = EG$

$AG = 1/2 + \sqrt{5}/2 = (1 + \sqrt{5})/2 = 1.618$

Ratio of the sides = AD: AG = 1 : 1.618

The rectangle AGFD is golden rectangle. From this rectangle, if the square ABCD is removed, the remaining rectangle BGFC becomes another golden rectangle.

One startling feature of the golden ratio is that we produce its square by simply adding the number 1; i.e., $\Phi^2 = \Phi + 1$.

Golden ratio in nature

The following two figures show the construction of a golden spiral and its nearest match in nature (mollusc shells).

In case of the daisy flower, the florets that make up this pattern (here represented by arcs) grow at the meeting points of two sets of spirals, which move in opposite directions, one clockwise, the other counter clockwise. If we connect the consecutive meeting points of these two sets of opposite lines, we can see the daisy's growth spirals. These spirals are logarithmic and also equiangular, since the angle they describe with the radii remain always the same.

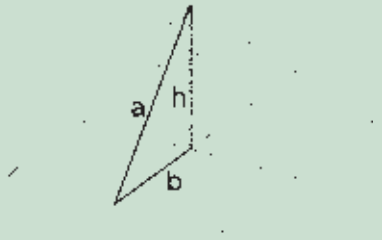
Daisy flower

Golden ratio in architecture

Both Egyptian pyramids and those mathematical regular square pyramids that resemble them can be analysed with respect to the golden ratio. A pyramid in which the apothem (slant height along the bisector of a face) is equal to ϕ times the semi-base (half the base width) is called a golden pyramid.

Some artists and architects believe the

Golden pyramid



Height of pyramid = h

If $h^2 = a \times b$ then $a/b = \Phi$

Using Pythagoras theorem,

$a^2 = h^2 + b^2$

$\Rightarrow a^2 - b^2 = h^2 = a \times b$

$\Rightarrow a^2 = a \times b + b^2$

$\Rightarrow a^2/b^2 = a/b + 1$

If $a/b = \Phi$, then

$\Phi^2 = \Phi + 1$, which is the feature of golden ratio.

Hence the pyramid shown above is golden pyramid.

Golden ratio and the Fibonacci series

Fibonacci sequence is a recursive series of numbers where the following number is equal to the sum of the previous two. The sequence goes like, 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, …….. and so on. The Fibonacci series is named after Italian mathematician Leonardo of Pisa (1170 – 1250) (more commonly known as Fibonacci.

There is a special relationship between the golden ratio and the Fibonacci series. Ratio of any two successive numbers in Fibonacci series is close to the golden ratio (1.618025....).

A	B	B/A
2	3	1.5
3	5	1.666666666...
5	8	1.6
8	13	1.625
13	21	1.615384615...
...	...	...
144	233	1.618055556...
233	377	1.618025751...

- $\Phi^2 = 1\Phi + 1$
- $\Phi^3 = 2\Phi + 1$
- $\Phi^4 = 3\Phi + 2$
- $\Phi^5 = 5\Phi + 3$
- $\Phi^6 = 8\Phi + 5$
- $\Phi^7 = 13\Phi + 8$
- . . .
- $\Phi^n = F(n)\Phi + F(n-1)$

F(n) is the n^{th} Fibonacci number.

Notice the Fibonacci Numbers on the right side of each equal sign (numbers in red and blue, separately form Fibonacci series).

Like golden ratio, there are amazing connections between Fibonacci numbers and natural forms (number of spirals in a pine cone, sunflower seed arrangement). There are boundless applications of Fibonacci series in geometry, number theory, probability, and algebra, to name but a few.

All of these are astounding evidence of the deep mathematical basis of the natural world. The golden ratio and the Fibonacci series is evidence of the beauty of mathematics. The amazing phenomenon permeates just about everything - both in and outside of the world of mathematics.

golden ratio makes the most pleasing and beautiful shape. Many buildings and works of art have the golden ratio in them, such as the Parthenon in Greece.

Painting

Italian mathematician Bartolomeo de Pacioli (also known as Luca Pacioli, 1446 – 1517) wrote a book *De Divina Proportione* (About divine proportions). The subject was mathematical and artistic proportions and the book was illustrated by Leonardo da Vinci. The first part of the book describes the golden ratio from a mathematical point of view and also studies polygons.

Leonardo da Vinci's illustrations of polyhedra in the book were based on the golden ratio and he was of the view that some bodily proportions exhibit the golden ratio. Some scholars speculate that Leonardo da Vinci incorporated the golden ratio in his paintings. However, it is not supported by Leonardo's own writings.

Early History

Ancient Greek mathematicians first studied the golden ratio because of its frequent appearance in geometry. The division of a line into the golden section is important in the geometry of regular pentagons and pentagrams. Euclid defined a proportion derived from a simple division of a line into what he called its "extreme and mean ratio".

Euclid's *Elements* (300 B.C.) provides the first known written definition of the golden ratio. In Euclid's words:

'A straight line is said to have been cut in extreme and mean ratio when, as the whole line is to the greater segment, so is the greater to the lesser.'

Figure 2

If the ratio of the length AC to that of CB is the same as the ratio of AB to AC, then the line has been cut in extreme and mean ratio, or in a golden ratio.

Evidence exists that the ratio may have been known to the ancient Egyptians (1650 BC). Egyptians referred it as the "sacred ratio". The ratio of the altitude of a face of the Great Pyramid at Gizeh to half the length of the base is 1.618. Through the ages other names have been attached to this wonderful ratio including golden mean, golden number, and divine proportion.

However, golden ratio did not get immediate acceptance with mathematicians. One story is that when the Greek mathematician Hippasus of Metapontum discovered in the fifth century B.C. that the golden ratio is a number that is neither a whole number (like 1,2,3…) nor even a ratio of two whole number (like fractions1/2, 2/3, 3/4,…; known collectively as rational numbers), this absolutely shocked the other famous mathematician Pythagoras (the Pythagoreans). The Pythagorean worldview was based on extreme admiration for the numbers – the intrinsic properties of whole number or their ratios – and their presumed role in the cosmos. The realisation that there exist numbers, like the golden ratio, that go on forever without displaying any repetition or pattern caused a true philosophical crisis.

It is not known with certainty how irrational numbers – numbers that are neither whole nor fractions – were discovered. Nevertheless, some researches do place the discovery in the fifth century B.C. What is clear is that the Pythagoreans basically believed that existence of such numbers was

The remarkable Ramanujan and the golden ratio

Srinivasa Ramanujan was a mathematical genius who had the ability look into the depth of mathematics. He created beautiful equations that became humankind's vast storehouse of knowledge. Ramanujan was an expert on infinite series, continued fractions and identities. Ramanujan's equations, once comprehended, unfold beautiful mathematical symmetry.

The following equation demonstrate his artistry

$$\frac{1}{1+\frac{e^{-2\pi}}{1+\frac{e^{-4\pi}}{1+\ddots}}} = \left[\sqrt{\left(\frac{5+\sqrt{5}}{2}\right)} - \frac{\sqrt{5}+1}{2}\right].e^{\frac{2}{5\pi}}$$

What is hidden at the right side of the equation is the golden ratio $\left(\Phi = \frac{\sqrt{5}+1}{2}\right)$.

Also $\frac{5+\sqrt{5}}{2} = 2 + \frac{\sqrt{5}+1}{2}$

Therefore, if Φ is substituted in the equation, we get the following:

$$\frac{1}{1+\frac{e^{-2\pi}}{1+\frac{e^{-4\pi}}{1+\ddots}}} = \left(\sqrt{2+\Phi} - \Phi\right).e^{\frac{2}{5\pi}}$$

The expression includes an infinite continuing fraction, e, π and the golden ratio (Φ). It is interesting to see how the golden ratio inevitably placed itself in one of the equations of the greatest mathematician of twentieth century.

Srinivasa Ramanujan
(1887 – 1920)

so horrific that it must represent some sort of cosmic error, one that should be suppressed and kept secret!

The modern history of the golden ratio starts with Luca Pacioli's *De Divina Proportione* in 1509, which captured the imagination of artists, architects, scientists.

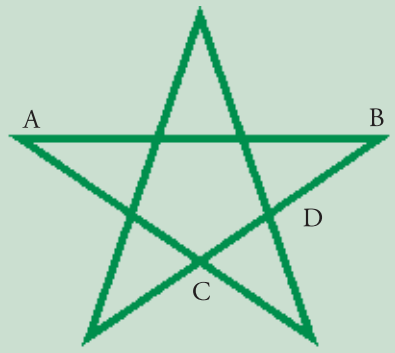
Irrational number

The fact that the golden ratio cannot be expressed as a fraction (as a rational number) means simply that the ratio of two lengths AC and CB in figure 2 cannot be expressed as a fraction. In other words, no matter how hard are search we cannot find some common measure that is contained, let's say, 31 times in AC and 19 times in CB. Two such lengths that have no common measure are called incommensurable. The discovery that the golden ratio is an irrational number was therefore, at the same time, a discovery of incommensurability.

New discoveries

In 2010, the journal *Science* reported that the golden ratio is present at the atomic scale in the magnetic resonance of spins in cobalt niobate crystals. Researchers have for the first time observed a nanoscale symmetry hidden in solid state matter. They have measured the signatures of a symmetry showing the same attributes as the golden ratio. The observed resonant states in cobalt niobate are a dramatic laboratory illustration of the way in which mathematical theories developed for particle physics may find application in nanoscale science and ultimately in future technology.

Pentagram



The golden ratio plays an important role in constructing regular pentagrams.
AB/AC = BC/BD = BD/DC = Φ

Conclusion

Some of the greatest mathematical minds of all ages, for Pythagoras to Euclid in ancient Greece, through the medieval Italian mathematician Leonardo of Pisa and the Renaissance astronomer Johannes Kepler, to present day scientists, have spent endless hours over this simple ratio and its properties. But the fascination with the golden ratio is not just confined to mathematicians, biologists, artists, musicians, historians, and architects; psychologists have pondered and debated the basis of its ubiquity and appeal. In fact, it is probably fair to say that the golden ratio has inspired thinkers of all disciplines like no other number in the history of mathematics.

Sources

Scott Olsen, The Golden Section: Nature's Greatest Secret

R. A. Dunlap, The Golden Ratio and Fibonacci Numbers

An excellent account on the golden ratio may be found at: http://en.wikipedia.org/wiki/Golden_ratio

Myths, Superstitions, and Scientific Temper

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We live in an age of contradictions. On the one hand we have sent spacecraft to the remote corners of the universe to look deeper into its structure and nature, on the other a large majority of our people still are dead scared to go out in the open when the shadow of the Moon falls on Earth. In an age where advances in medical science has succeeded in wiping out many of the scourges of the past that used to kill millions, people still castigate mothers for giving birth to a girl child. Female foeticide still continues in unabated. Belief in astrology is rampant, as evident from the popularity of TV channels dishing out daily forecasts and the rush for gemstones and amulets in quest of better luck. There are god men who perform so-called miracles, materialising precious object out of nothing, or offer ashes by rubbing his fingers on a coin. For a gullible devotee, the world seems to be steeped in magic and only those blessed with divine powers can understand it. In general, there is a general propensity to have blind faith in myths and superstitions, mainly because of a total lack of scientific temper.

Scientific temper has been defined in various ways. Basically, scientific temper is a mindset that helps one in taking rational decisions based on rational arguments. Most of the myths and superstitious beliefs cannot be explained by rational arguments. The word that needs to be stressed here is 'rational'. Scientific temper need not always have to do with something in science but more with reasoned and rational judgment. As Jawaharlal Nehru wrote in his *Discovery of India*, "Science deals with the domain of positive knowledge but the temper which it should produces goes beyond that domain."

Scientific temper invariably implies refusal to accept anything without questioning, be it an astrologer's prediction or certain taboos which abound in our country. Unfortunately, in the Indian society by and large, questioning is not only discouraged but even punished. Children in India grow up in an environment in which the words of the elders or gurus are taken as gospel truth. Scientific temper can hardly flourish in such an environment.

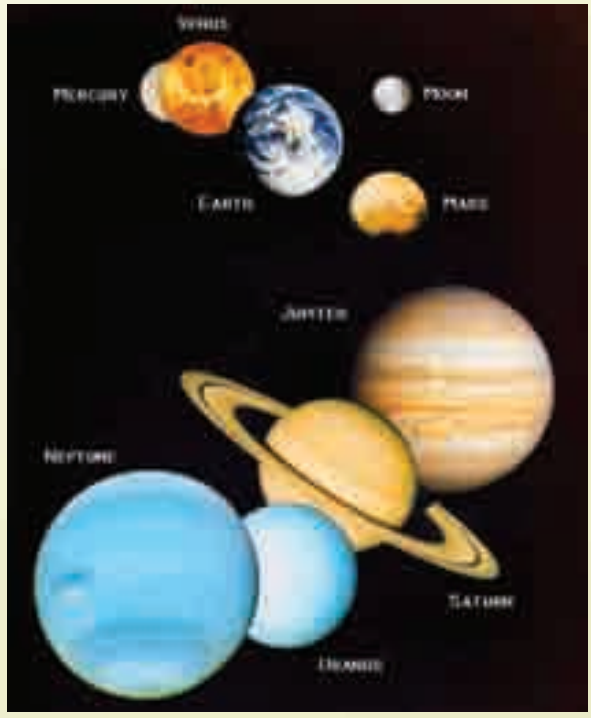
Astrology

Astrology continues to be the driving force behind a large majority of our people irrespective of their educational status, although it goes against the very spirit of scientific temper. Astrology – whether Western or Indian – cannot be classified as

Astrology continues to be the driving force behind a large majority of our people although it goes against the very spirit of scientific temper.

a scientific discipline for various reasons. In fact, it would not be an overstatement to say that astrology is a product of human ignorance and fear. Although people who lived 3,000 years ago were excellent sky watchers, they could not explain everything they observed. They could not explain the regular change of the pattern of stars in the night sky, the changing phases of the Moon, and the apparently erratic motion of certain star-like objects called planets in the night sky. They also could not explain the sudden appearance of comets – the strange-looking 'stars with tail' that seemed to appear from nowhere. It is quite possible that these early people also found that some events in their life appeared to be linked with the appearance of some constellation or the position among the stars of some of the 'star-like' objects that appeared to move erratically. This may have led them to believe that the position of the celestial bodies had an influence on their life. But that was several thousand years ago, when human knowledge of the universe was limited to naked-eye observation and astronomy was not yet a scientific discipline.

But today we have a reasonably clear idea of the scale of the universe and the real nature of stars and planets. Stars, except our Sun, are too far away to have any effect on the destiny of Earth's inhabitants. The constellations are nothing more than arbitrary imaginary shapes formed by a few bright stars in the sky. All the planets have been explored at close range by space probes, many of which have even landed on them. Humans have set foot on the Moon. From our present knowledge of the planets, on the basis of scientific data and images sent back by space probes, we know that the planets are made up of many of the same elements as our Earth although the composition of each



From our present knowledge of the planets and stars there is no reason to believe that they can influence our life.

planet differs. Comets no more arouse fear in our minds because we know where they come from and how they move.

Besides, astrologers are unable to explain why a planet in a particular position in the sky should influence an individual in a particular way and how it can do it given the large distances that separate the planets from us. Astronomy tells us that for at least two hours on average there is little likelihood of the Sun, Moon and the planets do not change constellations, which means that all babies born at a particular place within two hours are likely to have the same set of planetary positions as well as those of the Sun and the Moon. In other words, their horoscopes would be almost identical and they would all have similar fate. But it has been proved by compiling and analysing birth data babies born in the same city within a short span of time that this does not hold true.

So there is nothing to support the belief that planetary positions at the time of our birth or any other time can decide our personality or fate, as astrologers would like us to believe. But unfortunately, despite so much information being available about the planets and the stars and constellations people still believe in astrology and go for expensive rituals and gemstones to counter 'evil influences' of planets. Almost every other television channel today devotes hours every day to telecast astrological 'forecasts' and even suggests astrological solutions for viewer's problems. Many newspapers carry daily astrology columns.

Many proponents of astrology in India take pride in claiming that astrology has its origins in the Vedas. But this is also a myth. The renowned Indian theoretical astrophysicist Prof. Jayant V. Narlikar writes in his book *The Scientific Edge*:

One should be very wary of anything declared to be Vedic or of ancient origin. Since India had an oral tradition of transmission of knowledge, very few reliable records of this ancient epoch are extant. The situation is thus different from that prevailing in other cultures like China, Arabia or medieval Europe where written traditions existed. What written works we have may well contain the *prakshipta* (later additions to a manuscript).

According to Prof. Narlikar, we have to look at the claim of Vedic astrology keeping in view the above facts.

He further adds:

A survey of Vedic literature fails to reveal instances of nine 'planets' and their supposed influence on human destiny. There are references to omens and also to sacrifices to be performed at different times of the year as determined by the positions of constellations. The seven-day week came to India from the Greeks through the Arabs.

Eclipses

Solar and lunar eclipses are common natural phenomena that are seen regularly. There are many myths attached to eclipses. A lunar eclipse does not evoke as much awe and wonder as a solar eclipse does, especially if the eclipse is total. A total solar eclipse is without doubt the most spectacular natural phenomenon one can ever witness. Yet there are many who are dead scared of a solar eclipse and refuse to go out and witness the magnificent spectacle because of various myths connected with eclipses.

A solar eclipse is a simple astronomical phenomenon, caused by the shadow of the Moon falling on Earth, but many people still are scared of it.

During a solar eclipse the Sun appears to be 'devoured' by a black circular body, which ancients presumed to be a demon. During totality the Sun is totally obliterated and replaced by a dark disc. Since the Sun was regarded as a God, its disappearance in the sky was considered ominous, which called for taking bath, prayers, and fasting. Some people even claimed that dangerous rays come out of the Sun during an eclipse. But there is nothing further from the truth.

Today we know that a solar eclipse is nothing but the shadow of the Moon falling on Earth. As the Earth orbits the Sun and the Moon orbits the Earth there are occasions when the Moon comes between the Sun and Earth in a straight line. When such an alignment happens the shadow of the Moon falls along a narrow path on Earth's surface from where the Sun appears to be totally obliterated from the sky.

In reality, the shadow of the Moon is no different from the shadow cast by an umbrella on a sunny day or the shadow cast by passing clouds. All are produced by an opaque object coming in the path of light from the Sun. Moreover, during an eclipse nothing really happens to the Sun, which stays 150 million kilometres away; it continues to radiate light and heat like it does at any other time. So, for the Sun, an eclipse is of no consequence. It is us humans who get the jitters for all wrong reasons. All the fear and the taboos of not cooking, eating, or going to the toilet during an eclipse have no rational basis. People tend to follow these taboos simply out of unfounded fear.

Belief in myths about eclipses is not confined to ordinary folks; even educated people in positions of responsibility, whom people look forward to for guidance, appear to be equally gullible. At an orientation camp for children organised in Bhopal before the total solar eclipse in July 2009, the then state minister for science and technology not only exhorted the children to follow the traditional taboos of not eating and cooking during an eclipse but went further to claim that if girls watered a *tulsi* plant regularly they would get ideal husbands! If a minister for science and technology can make such blatantly unscientific statements what kind of scientific temper are we talking about?

Gender bias

Even in the twenty-first century, countless women in India have to suffer because they happen to give birth to female babies. Despite advances in genetics and teaching of biology

in schools, a substantial number of people, especially in villages but also in cities, believe that the mother is solely responsible for birth of a girl child although it is really the sperm from the father that decides the gender.

Yet another common myth is that birth of a son is a must to ensure salvation after death – a belief steeped in blind faith without any rational logic. So great is the urge to have a son that couples are known to have ended up having six or seven daughters but no son! The obsession with male child is so strong that female foeticide remains a chronic social problem.

Blind faith in myths is so strong that some people would make us believe that cats can decide our fate. Otherwise why would one be scared to see a black cat crossing the road? It is common knowledge that few drivers would dare to drive their vehicle and continue on their journey after seeing see a black cat crossing the road, but they cannot explain why they do it. Again, here too, there is no rational explanation and only a lack of scientific temper prevents people from questioning such baseless myths.

Another common myth is that if someone sneezes before going somewhere or starting some work, there will be some obstacle in the way. It is usually advised to stop for some time after sneezing. Here also there is no scientific basis for such a belief. A sneeze is the result of a reflex through which the body rids the respiratory system of harmful germs, irritants and congestion. It is an action that is automatic and beyond an individual's control. Normally, people sneeze when an irritant enters the nasal cavity; it has nothing to do with the success or failure of any human activity.

A black cat crossing the road is considered a bad omen, but there is no rational explanation and only a lack of scientific temper prevents people from questioning such baseless myths.

Many of the myths discussed above could be busted if their believers had the ability to think logically. Article 51 A of our constitution, which deals with fundamental duties, makes it a duty of every citizen to develop a scientific temper. But in a country like India, which has a large section of the population that is illiterate and lives below the poverty line, any talk of scientific temper needs to be tempered by ground reality. For people who have to struggle hard to get even one meal a day scientific temper may mean nothing. They would be more prone to believing in myths that promise them a better life; of course, it is a different matter if they get any succour in this way. It is therefore important that economic uplift, widespread education, and unrestricted communication are ensured before people can be made to understand the significance of scientific temper in their life. Otherwise they would continue to be motivated by myths and superstitions rather than by scientific reasoning. ■

Sleep Apnoea

Diagnosis, Remedies and Treatments

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Sleep apnoea is a potentially serious disorder. It is characterised by repeated temporary interruption of breathing during sleep. You might awaken with a transient shortness of breath that corrects itself quickly, within one or two deep breaths, or you may make a snorting, choking or gasping sound. This pattern can repeat itself five to 30 times or more each hour, all night long. These disruptions impair your ability to reach the desired deep, restful phases of sleep, and you'll probably feel sleepy during your waking hours.

Sleep hath its own world,
And a wide realm of wild reality.
And dreams in their development have breath,
And tears, and tortures, and the touch of joy.
– Lord Byron, *The Dream*

Your doctor may make an evaluation based on your signs and symptoms or may refer you to a sleep disorder centre. There, a doctor who's a sleep specialist can help decide whether you need further evaluation.

Tests and diagnosis

The evaluation may involve overnight monitoring of your breathing and other body functions during sleep. Tests to detect obstructive sleep apnoea include:

Sleep lab studies

Sleep lab studies monitor the changes in body processes during a period of normal sleep. During this test, also referred to as "nocturnal polysomnography" you're hooked up to equipment that monitors your heart, lung and brain activity, breathing patterns, blood pressure, movements of the chest wall and abdomen, arm and leg movements, and blood oxygen levels while you sleep.

This can help your doctor rule out other conditions — such as periodic limb movements or narcolepsy — that can also cause excessive daytime sleepiness, but require different treatment. If you undergo testing in a sleep laboratory, you may need to stay overnight.

Oximetry

This screening method involves using a small machine that monitors and records your blood oxygen level while you're asleep. A simple sleeve fits painlessly over one of your fingers to collect the information overnight. This can be done both at a sleep lab and at home.

If you have obstructive sleep apnoea, the results of this test will often show drops in your blood oxygen level during apnoeas and subsequent rises with awakenings. If the results are abnormal, your doctor may have you undergo polysomnography to confirm the diagnosis. However, oximetry doesn't detect all cases of obstructive sleep apnoea. So even if the oximetry results are normal, your doctor may still recommend a polysomnogram.

Portable at-home testing

Under certain circumstances, your doctor may provide you with at-home tests to diagnose obstructive sleep apnoea. These tests usually involve oximetry, measurement of airflow and measurement of breathing patterns.

Visiting an ENT Doctor

Your family doctor also may decide to send you to an ear, nose and throat specialist. The basic idea is to rule out any anatomic blockage in your nose or throat.

X-rays, CT scan and Endoscopy

If the doctor suspects that your upper airway is compromised due to enlarged tonsils, adenoids, or lymphoid tissue, he or she may advise you to undergo an X-ray, a CT scan or an endoscopic examination of the region.

Lifestyle changes and home remedies

If you are a mild case of obstructive sleep apnoea, your doctor may suggest certain lifestyle changes and home remedies. These may work very well and relieve you of sleep apnoea — try them out:

Lose weight

Even a slight loss of excess weight may help relieve the constriction of your airway. Losing about 10 kg may well cure you of the disorder.

Quit smoking

Smoking is a known culprit. It also leads to obstructive sleep apnoea. You must give up, if you wish to get rid of the snoring and that stop-start-snorty breathing during sleep.

Avoid alcohol

Drink alcohol moderately, if at all, and don't drink several hours before bedtime. It relaxes the muscles in the back of your throat, and interferes with breathing.

Avoid tranquillisers and sleeping pills

Some medications such as tranquillisers and sleeping pills relax the muscles in the back of your throat, and interfere with breathing. Avoid them as far as possible.

Don't sleep on your back

Sleep on your side or abdomen rather than on your back. Sleeping on your back can cause your tongue and soft palate to rest against the back of your throat and block your airway. To prevent sleeping on your back, try sewing a tennis ball in the back of your pyjama top.

Use a saline nasal spray

Keep your nasal passages open at night. If you have congestion, use a saline nasal spray to help keep your nasal passages open. Applying desi ghee in the nostrils also works well for some.

If you need nasal decongestants or antihistamines, talk to your doctor before using them. Unlike saline sprays, these medications are generally recommended only for short-term use.

Therapies

If these measures don't improve your sleep or if your apnoea is moderate to severe, you could consider other treatments. Certain devices can be used to open up a blocked airway.

Continuous positive airway pressure (or CPAP)

If you have obstructive sleep apnoea, you may benefit from a machine that delivers air pressure through a mask placed over your nose while you sleep. The most common type is called continuous positive airway pressure, or CPAP.

With this treatment, the pressure of the air breathed is continuous and somewhat greater than that of the surrounding air, which is just enough to keep your upper airway passages open. This prevents obstructive apnoea and snoring.

There are two types of CPAP — fixed and autotitrating. Fixed CPAP delivers airway pressure at a constant level. Autotitrating adjusts the level of pressure if it senses increased airway resistance.

Although CPAP is the most consistently successful and most commonly used method of treating obstructive sleep apnoea, some people find it cumbersome and uncomfortable. With some practice, most people learn to adjust the mask to obtain a comfortable and secure fit. You may need to try different types to find a suitable mask. If you're having particular difficulties tolerating pressure, there are machines that have special adaptive pressure functions to improve comfort. Many people also benefit from using a humidifier along with their CPAP system.

Bi-level positive airway pressure (BPAP)

There are also bi-level positive airway pressure (BPAP) appliances, which deliver a preset amount of pressure when you breathe in and a different amount of pressure when you breathe out.

CPAP is more commonly used because it is been well studied for obstructive sleep apnoea. For people who have difficulty tolerating fixed CPAP, BPAP or autotitrating CPAP may be worth a try.

Don't stop using your positive airway pressure machine if you have problems. Check with your doctor to see what adjustments you can make to improve its comfort. In addition, contact your doctor if you still snore despite treatment or begin snoring again. If your body weight changes, your doctor may need to adjust the pressure settings.

Simple mouthpiece device

While positive airway pressure is nearly always an effective treatment, oral appliances are a successful alternative for some people. These devices are designed to keep your throat open. Some do so by bringing your jaw forward, which can sometimes relieve snoring and obstructive sleep apnoea. Others hold your tongue in a different position.

If you and your doctor decide to explore this option, you'll need to see a dentist experienced in dental sleep medicine appliances for the fitting and follow-up therapy. A number of devices are available. Close follow-up is needed to ensure successful treatment.

Surgical options

The goal of surgery for obstructive sleep apnoea is to prevent blockage of the upper airway during sleep. Several surgical options exist.

Surgery of the upper throat

Uvulopalatopharyngoplasty, or UPPP for short, is a procedure in which your doctor removes tissue from the rear of your mouth and top of your throat. Your tonsils and adenoids are commonly removed as well. This type of surgery may be successful in stopping throat structures from vibrating and causing snoring.

UPPP usually is performed in a hospital and requires a general anaesthetic.

Jaw surgery

In this procedure, called maxillomandibular advancement, the upper and lower parts of your jaw are moved forward from the rest of your facial bones. This enlarges the space behind the tongue and soft palate, making obstruction less likely. This procedure requires an oral surgeon and possibly an orthodontist, and at times may be combined with another procedure to improve the likelihood of success.

Surgical opening in the neck

You may need this form of surgery if other treatments have failed and you have severe, life-threatening obstructive sleep apnoea. In this procedure, called a tracheostomy, your surgeon makes an opening in your neck and inserts a metal or plastic tube through which you breathe. You keep the opening covered during the day. But at night you uncover it to allow air to pass in and out of your lungs, bypassing the blocked air passage in your throat.

Implants

The Pillar procedure is a minimally invasive treatment that involves placement of three tiny polyester rods in the soft palate. These inserts stiffen and support the tissue of the soft palate and reduce upper airway collapse and snoring. This treatment is recommended only for people with mild obstructive sleep apnoea.

Other types of surgery

Some other types of surgeries may also help reduce snoring and sleep apnoea by clearing or enlarging air passages. These include nasal surgery to remove polyps or straighten a crooked partition between your nostrils (deviated nasal septum); and surgery to remove enlarged tonsils or adenoids. ■

Continued from page 39 **(On mathematics)**

of mathematical inquiry by the efforts of a group of Italian mathematicians working through 1520s and 1540s.

Geometry developed as a recognised branch of science by the works of Pythagoras, Euclid and Archimedes was revitalized by the invention of co-ordinate geometry by Rene Descartes. Blaise Pascal and Pierre de Fermat developed probability theory, John Napier invented logarithms, and Isaac Newton and Gottfried Leibnitz developed calculus. Nikolai Lobachevsky rejecting Euclid's parallelism developed non-Euclidean geometry, a more developed form of which by George Riemann was later utilised by Albert Einstein in his theory of relativity. Mathematical physics acts as a bridge between physics as description of nature and its structure on the one hand and mathematics as the construction of pure logical and abstract thought.

The year 2012 has been declared as the National Mathematical Year by the Government of India to commemorate the 125th birth anniversary of Srinivasa Ramanujan, one of the greatest mathematicians of all time. A number of activities including popular lecture series have been planned to cater to the diverse sections of the society.

Mathematics is expected to remain in focus in 2013 because in the year 2013 a number of activities are proposed to be undertaken under a wide umbrella of initiatives called the Mathematics of the Planet Earth (MPE-2013). The idea behind MPE-2013 is to focus on mathematical research in areas of relevance to the various processes that affect the Earth. The themes proposed to be pursued under the aegis of MPE-2013 are: 1) A planet to discover (oceans, meteorology and climate, mantle processes, natural resources, celestial mechanics); 2) A planet supporting life (ecology, biodiversity, evolution); 3) A planet organised by humans (political, economic, social and financial systems, organisation and communication networks, management of resources, energy); and 4) A planet at risk (climate change, sustainable development, epidemics, invasive species, natural disasters). The relevance of mathematics in the areas covered lies in the fact that mathematics is used as a universal language and tool for any quantitative research in all the sciences, including biology, economics, geography, and so on. Fundamental mathematical questions may arise out of these research topics. Both these aspects will be highlighted by MPE-2013. Many international bodies including International Centre for Theoretical Science of the Tata Institute for Fundamental Research, Mumbai are partners in MPE-2013.

National Mathematical Year-2012 and Mathematics of Planet Earth-2013 should be utilised to create interest in mathematics in students and to make them aware of the importance of mathematics in understanding the secrets of nature and solving practical problems and to advance the frontier of human knowledge. There is no doubt that that it is possible to make an interesting and satisfying (both in terms of respectability and remuneration) career out of mathematics provided one excels in it. The National Mathematical Year should be seen as an opportunity to make people aware of India's mathematical heritage and to create an environment conducive for learning and pursuit of mathematical ideas so that India can reclaim its pre-eminent position in the world of mathematics. ■

Recent developments in science and technology

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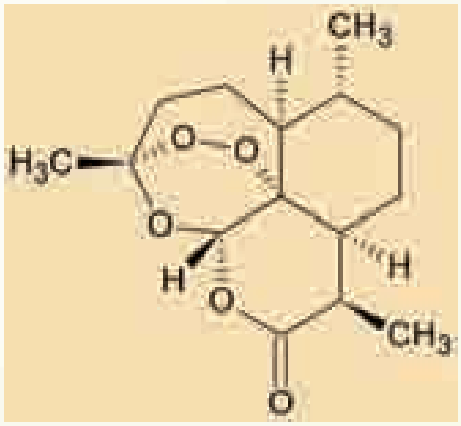
Cheaper drugs against malaria

Malaria is a mosquito-borne disease that kills millions, mostly in the poorer countries of the world, every year. Control of mosquito breeding is one the most effective means of preventing the spread of malaria. However, worldwide mosquito-control measures have been mostly ineffective and antimalarial drugs remain the only option to treat those infected with the malaria parasite. Quinine obtained from the bark of the cinchona tree was once the most effective antimalarial drug available, but it has become ineffective as the parasite has become resistant to it. The only effective antimalarial available today is artemisinin – a drug obtained from the sweet wormwood (*Artemisia annua*) plant, a herb described in Chinese traditional medicine. Since 2001, WHO has recommended that so-called artemisinin-based combination therapies (ACTs) – in which artemisinin is combined with another drug – replace older, ineffective drugs worldwide. These combinations have become a cornerstone of malaria control and are believed to have saved many lives.

But artemisinin is an expensive drug and beyond the reach of most patients in the poorer countries. ACTs still cost between $1 and $2 per treatment course, which the poor patients can hardly afford. Now there is hope for these patients. Scientists



Artemisinin molecule

at the Max Planck Institute of Colloids and Interfaces in Germany have developed a simple method of synthesising the artemisinin molecule, which can drastically reduce the cost of the drug. The synthetic process uses artemisinic acid, a by-product left over after extraction of artemisinin from sweet wormwood leaves. During the extraction of 1 kilogram of artemisinin, as much as 10 kilograms of artemisinic acid is produced, which is currently thrown away because its conversion into artemisinin is not cost-effective. Now, chemist Peter Seeberger and his colleague François Lévesque say they may have solved that problem. They have developed an inexpensive three-step continuous flow synthesis of artemisinin from artemisinic acid using a combination of oxygen and ultraviolet light. They could convert artemisinic acid into artemisinin in just four-and-a-half minutes in a continuous-flow reactor. (*Angew. Chem.*, Int. Ed. | 2012, DOI: 10.1002/anie.201107446).

The two chemists began by reducing artemisinic acid to dihydroartemisinic acid, prior to the critical synthetic step of reacting it with singlet oxygen to form a hydroperoxide. The highly reactive singlet oxygen molecule must be produced by a photochemical reaction, which can be induced only by using light. But since light only penetrates a limited distance into batch reactors this could pose a problem for commercial production. However, by pumping reagents continuously through tubes wrapped around a lamp, Seeberger and Lévesque could illuminate the entire solution efficiently. Using the method they could produce as much as 800 grams of artemisinin per reactor per day, which was quite substantial.

According to Seeberger, the production could be raised to 2 kg per day and when that happens the entire world's supply of the drug for a year could be produced by just 150 reactors. It could also cut the cost of the drug to about one-fifth its present cost and end the global shortage and the high prices of artemisinin.

Artemisia plant

Hepatitis C vaccine made with chimpanzee virus

Hepatitis C is a viral disease that leads to swelling (inflammation) of the liver. Most people who were recently infected with hepatitis C do not have symptoms. About 10% have jaundice that gets better. However, if the infection has been present for many years, the liver may be permanently scarred, a condition called cirrhosis. In many cases, there may be no symptoms of the disease until cirrhosis has developed. Many patients with hepatitis C benefit from treatment with medications. The most common medications are a combination of a type of interferon called 'pegylated interferon alpha' and the antiviral drug ribavirin. Hepatitis

Chimpanzee adenovirus is helping make an effective hepatitis C vaccine

C virus is estimated to infect 170 million people globally. Currently there is no vaccine to protect against hepatitis C.

But the situation may change soon with the development of a vaccine against hepatitis C based on a chimpanzee virus. At present many vaccines use human adenoviruses as carriers of the weakened viruses as antigens into human cells. [Adenoviruses are a frequent cause of the common cold and upper respiratory tract infection in humans.] In vaccines, genes encoding antigens for a specific pathogen are packaged into the virus. Once released into cells, the antigens trigger a protective immune response.

But there is one major problem with using human adenovirus. Patients already exposed to human adenoviruses naturally develop antibodies against them, which then neutralise the vaccine before it has a chance to deliver its package, thus making the vaccine ineffective. This is because once the body develops immune response it stays for the rest of its life and this pre-existing immunity gets rid of the weakened virus in the vaccine before it can stimulate a new immune response.

To get over this problem a team of researchers have now come up with the idea of using chimpanzee adenovirus to make vaccines against hepatitis C, which avoid the problem of pre-existing immunity that can prevent the vaccine from working. The results of two recent studies indicate that vaccines developed using chimp adenovirus as vectors can indeed trigger immune protection to hepatitis C. Both the studies were done by teams of British and Italian scientists and both involved the use of chimpanzee adenovirus as vectors for hepatitis C vaccine. One of the studies reports the successful clinical trial results for one such chimp virus-based vaccine for hepatitis C (*Sci Transl Med*, 4 January 2012).

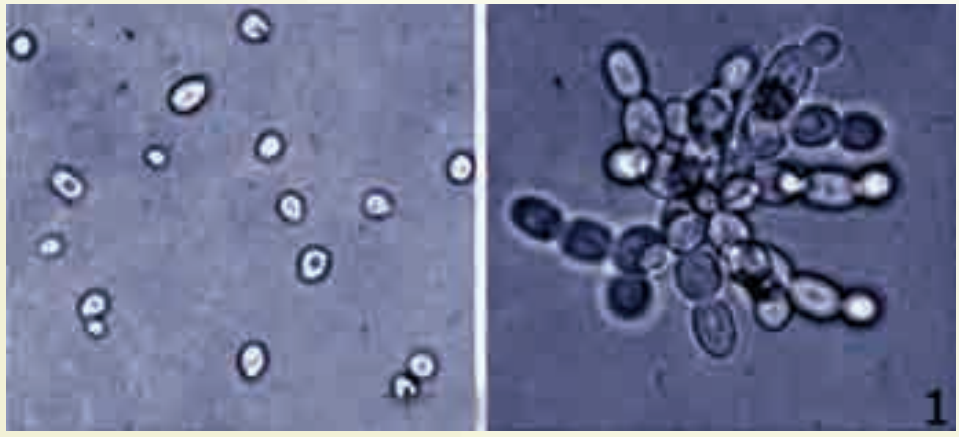
Before making the vaccines the researchers collected chimpanzee stool samples from zoos and animal facilities, and isolated and characterised almost 30 different chimp adenovirus strains from some 1,000 stool samples. They made safe forms of the viruses that were unable to replicate, and tested them for their immune potency in mice. The best ones, generating the biggest cellular immune responses, were chosen for making trial vaccines. In a separate phase 1 clinical trial, Eleanor Barnes at Oxford University and colleagues used one of the selected chimp vectors to deliver a potential hepatitis C vaccine to small groups of healthy human volunteers. According to the researchers, the chimp virus vector triggered a specific immune response to the virus, and appeared to be safe and well-tolerated.

Multicellular life created in laboratory

Single-cell organisms, such as bacteria and protozoa, have been so successful in adapting to a variety of different environments that they comprise more than half of the total biomass on Earth. Unlike many-celled or multicellular organisms, many of these unicellular organisms can synthesise all of the substances they need from a few simple nutrients, and some of them divide and multiply more than once every hour.

But multicellular organisms have certain advantages that single-cell organisms lack. For example, by collaboration and by division of labour multicellular organisms can exploit resources that no single cell could utilise so well. This principle, applying at first to simple associations of cells, has been taken to an extreme in the multicellular organisms we see today. Multicellularity enables a plant, for example, to become physically large; to have roots in the ground, where one set of cells can take up water and nutrients; and to have leaves in the air, where another set of cells can efficiently capture radiant energy from the Sun. However, despite it happening independently nearly two dozen times in the past, very little is known about the way the initial evolution from unicellular to multicellular life had taken place. This is because these transitions occurred some 200 million years ago.

One of the earliest steps in the evolution of multicellular organisms could be the association of unicellular organisms to form colonies. The simplest way of achieving this would be for daughter cells to remain together after each cell division. And this is what researchers William Ratcliff and his colleagues at the University of Minnesota in St Paul, Minnesota, wanted to find out using the common brewer's yeast (*Saccharomyces cerevisiae*), which is an unicellular organism. They wanted to see if they could evolve multicellularity in a single-celled organism. And their finding was really surprising. In



At left, an original strain of brewer's yeast. At right, the multicellular form. (Credit: Ratcliff et al./PNAS)

the lab, the yeast took less than 60 days to evolve into many-celled clusters that behaved as multicellular organisms. The clusters even developed a primitive division of labour, as seen in multicellular organisms, with some cells dying so that others could grow and reproduce (*Proceedings of the National Academy of Sciences*, 17 January 2012 | doi: 10.1073/pnas.1115323109).

For their study Ratcliff and his colleagues grew brewer's yeast in flasks of nutrient-rich broth and used gravity as the selective pressure. Once per day they shook the flasks, removed yeast that most rapidly settled to the bottom, and used it to start new cultures. Free-floating yeast were left behind, while yeast that gathered in heavy, fast-falling clumps were used for culturing. After many rounds of selection over 60 days, the yeast had evolved into 'snowflakes' comprising dozens of cells. The snowflake yeast clusters behaved like true multicellular organisms. They had a simple life cycle with a juvenile stage, when they grew unimpeded, and an adult one, when they reached a certain size and split into a large parent flake and a smaller, daughter flake. According to Ratcliff, the snowflake yeast clusters split because some of their component cells sacrifice themselves, allowing pieces to snap off. These individual cells die for the good of the whole, allowing the parent flake to continue growing and produce many offspring.

Errata

In the Desk calendar 2012 published by Vigyan Prasar on the theme 'Mathematics', the following changes may be noted:

- In the month of May (front), the number 5 in the number grid is a prime although not printed in red.
- In November (back): In the example of binary numbers, the expression: 1 x 22 + 0x21 + 1x20 should be replaced by: 1 x 2^2 + 0x2^1 + 1x2^0.
- In December (back): The captions 'Janaki, Ramanujan's wife' and 'Komalatammal, Ramanujan's mother' should be interchanged.

Series of National Level Workshops for Transit of Venus- 2012

Eclipse, when two objects of comparable sizes block each other, occultation, when a body with greater angular size blocks an object with smaller angular size and transits, when an object with lesser angular size come in between the observer and an object with greater angular size are some of the celestial wonders that naturally occur due to movements of the celestial bodies.

One such cosmic event, the Venus Transit- passing of Venus in front of Sun's disk will take place on the coming 06 June 2012. The transit of Venus occurs in pairs with one that took place on 08 June 2004. The next pair of transit of Venus will occur in 2117 and 2125, making it truly once in life time opportunity.

The first recorded observation of the transit of Venus was done by the British Priest, Jeremiah Horrocks, in 1639. Jeremiah Horrocks was the first who used his observations to measure the Earth to Sun distance, called the Astronomical Unit (AU). The upcoming Transit of Venus- 06 June 2012 will be a life time opportunity for everyone on the Earth. In India, on 06 June 2012, transit will commence well before sun rises and one can observe the phenomena on Sun's projected image or through approved solar filters supplied by authorised agencies from morning hours to mid morning.

Keeping this event as a peg, VP is proposing to organise a series of regional training programme in different parts of the country between April and May 2012 to train and make a set of resource persons on conducting Day Time Astronomy activities. Each participants of the workshop would have to undertake to initiate activities on Day time astronomy at least in ten villages/ schools.

Vigyan Prasar invites amateur astronomers, science activists, science communicators, teachers (School and college) who are desirous of joining the regional training programme, and who are ready to give undertaking that they will at least conduct 10 field level programmes subsequent to receiving the training may apply. The last date for application is **20 March 2012**.

The shortlisted applicants will be informed through mail/letter/phone by **01 April 2012**. The travel support restricted to AC-II and frugal accommodation at the place of training programme will be provided by Vigyan Prasar. You can apply online through our website www.vigyanprasasr.gov.in.

Application Form

*Name:.....

Contact address:.....

Email: .....

*Phone: .....

Do you represent any organisation/school/college: Yes / No

Name of the organisation/School/College (if any): .....

Do you have access to telescope or binocular? If yes, please mention the specifications:

.....

Since when you are involved in Astronomy communication and education:

.....

Provide the list of locations where you will be conducting similar workshops

Any astronomy events or projects organised by you:

Please justify, why you should be invited for the workshop? (Write about 150 words)

The filled application should reach on following address by 20 March 2012.

To,
'Application for TOV-2012'
Vigyan Prasar, A-50 Institutional Area, Sector 62, NOIDA, UP 201309

'Rashtriya Vigyan Chalchitra Mela and Competition (RVCM) – 2012'

During the 99th Indian Science Congress, Vigyan Prasar organised the Second Science Film Festival – the Rashtriya Vigyan Chalchitra Mela and Competition – at the Kalinga Institute of Industrial Technology (KIIT) University, Bhubaneswar. The festival was held from 4 to 7 January 2012. It was organised to facilitate, nurture, recognise and encourage outstanding science film producers. Bharat Jan Gyan Vigyan Samiti, Bhubaneswar was the local coordinator and provided local support and helped in coordination with KIIT University. This time, competition had three major categories; (a) Popular Science Programme (duration more than 20 mts); (b) Short Film on Science and Technology (duration less than 20 mts); and (c) Animation and Graphic film/video on Science and Technology. Two additional awards were in (d) Science Film made by student s), and (e) Special Jury Award.

The competition attracted outstanding science and technology video films produced in the country and set new bench marks for excellence. There were 59 entries received in different categories. Out of these, seven films in the 'Popular Science Programme' category; five in the 'Short film on Science and Technology' category; three in the 'Animation and Graphics film on Science and Technology' category; and three in the 'Science Film made by student(s)' category were shortlisted.

During the first three days shortlisted science films were screened which were well received by the viewers. The films under different categories for awards were selected by a national jury. Jury members were well known and prominent personalities of science communication. The team was lead by Ms. Suhasini Mulay, while Er. Gauhar Raza, Er. Anuj Sinha, Mr. U. Radhakrishnan, Dr. Prabhakar Singh, and Dr. T. V Venkateswaran were the members of the jury.

Dr. Arvind C. Ranade, Scientist 'D', Vigyan Prasar, briefing about RVCM 2012 in inaugural function

Dr. Achyuta Samanta, Patron of 99th session of Indian Science Congress 2012 addressing the gathering in inaugural fuction

The Science Film Festival was inaugurated on 4 January 2012 by Honorable Minister of Food Supply and Consumer Welfare, Government of Orissa Mr. Niranjan Pujari and Dr. Achyuta Samanta, Patron of 99th session of Indian Science Congress 2012. Dr. R N Ray, Chairman BJGVS, and Mr. Hemanshu Kathua, CEO, School of Film and Media, KIIT University were present. Dr. Arvind C Ranade, Scientist from Vigyan Prasar, briefed about the programme. The festival was well attended by school children, enthusiast film makers, producers, Science Congress delegates, and science communicators.

The award presentation ceremony

Audience during the screening of film in Kalinga Institute of Dental Sciences, KIIT Campus, Bhubaneswer

Award Winners with the Guest Dignitaries

The award winners

First Category: 'Popular Science Programme'

'Golden Beaver Award'

Film Title : 'Home – Our Garden of Eden'
Produced by : Suresh Elamon, Trivandrum
Directed by : Suresh Elamon, Mr. Trivandrum

'Silver Beaver Award'

Film Title : The Darwin Puzzle
Produced by : Suresh Elamon, Trivandrum
Directed by : Mr. Arjun Bhagat, IMAK News & Enterainment Pvt. Ltd., New Delhi

Second Category: 'Short films on Science & Technology'

'Golden Beaver Award'

Film Title : Magnet Part-1
Produced by : Deepak Verma
Directed by : Harkara Media, New Delhi

'Silver Beaver Award'

Film Title : Thalassemia Ek Chunoti
Produced by : Ms. Manisha Sharma
Directed by : Dirgha Media, Ahmedabad

Third Category: 'Animation and graphics films on science & technology'

'Silver Beaver Award'

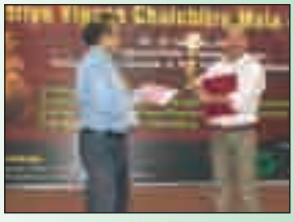
Film Title : I Love You Humans
Produced by : Mr. V. Murgan, Chennai
Directed by : Mr. M. Rajkumar, Chennai.

Fourth Category: 'Science Film made by Student(s)'

'Special Award'

Film Title : To Be A Smoker Or Not To Be
Produced by : Akanksha, Vindushritha, Varshinya, Anushka and Anviksha
Directed by : Indus International School, Bangalore.

Special Jury Award



'Special Jury'

Film Title : To Be A Smoker Or Not To Be
Produced by : Akanksha, Vindushritha, Varshinya, Anushka and Anviksha
Directed by : Indus International School, Bangalore.

Certificate of Merit

- The Life and Times of P.C. Ray, Vigyan Prasar, New Delhi, Mr. Arjun Bhagat, IMAK News & Entertainment Pvt. Ltd., New Delhi;
- Hatyare Kee Hatya: The Story of Vaccines, Vigyan Prasar, New Delhi, Ms. Seema Muralidhara, Beacon Television;
- Khatta Meetha: The Story of Controlled Experiments, Vigyan Prasar, New Delhi, Ms. Seema Muralidhara, Beacon Television;
- Chandra: In Quest of Perspectives, Indian Institute of Science Education and research (IISER) Pune, Mr. Nandan Kudhyadi, Pune;
- Mangroves: Guardians of the Coast, Mr. Abdul Fazili and Mr Tenzing Khapak, Mike H. Pandey, Riverbank Station, New Delhi;
- Properties of Water (Pani Ke Gunn), CIET, NCERT, Ms. Anita Gupta;
- India's First in Science & Technology, Television Programme Company, New Delhi, Mr. Matiur Rahman;
- Targeted Drug Delivery System, Matiur Rahman, Television Programme Company, Dr. J. N. Verma, Life Care Innovations;
- Friction My Friend, Mr. Alok Ranjan, Jahangirabad Media Institute, Jahangirabad, U.P.; and
- Refraction, Mr. Mo. Tabish Anwar, Jahangirabad Media Institute, Jahangirabad, U.P.

was held at Kalinga Institute of Dental Sciences Auditorium within the campus of KIIT University on 7 January 2012 at 03:00 PM. Dr. Achyuta Samanta, was the Guest of Honour and Mr, Pramod Prakash Panda, Head, Infosys Bhubaneswar was the Chief Guest at the awards ceremony. The function was attended by Dr Subodh Mahanti, Honorary Director, Vigan Prasar. The awards were presented to all the winners under different categories while shortlisted films were given the certificate of merit. The entire programme was coordinated by Dr Arvind C Ranade, Scientist from Vigyan Prasar.

Report Made by the coordinator of the Programmme: Dr Arvind C Ranade. ■

Letters to the editor

Excellent magazine

Dream2047, is an excellent magazine because there is a lot of interesting and informative material in it. This magazine is most useful for educational institutions, science students and also science clubs.

Mr. Nishant Gaurav
S/o Mr. Ramjee Tiwari
Vill./Post: Piprahi, Distt.: Sheohar
Bihar – 843334

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Useful for science communicators in regional languages

The articles published in *Dream 2047* are very useful to science communicators, particularly in regional languages, as they provide up-to-date information on latest science topics. Recently I have delivered a radio talk over A.I.R., Warangal Station in Telugu based on "Genetically Modified Food: Boon of Bane?" by N. Ramdas Iyer, which appeared in *Dream 2047*, April 2011 (pages 35-33).

Dr. Sammeta Govardhan
3-13-156, Kumarpally
Hanamkonda – 506001

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Mythology and science

I agree with the author that there is no scientific evidence that our solar system had two Suns in remote past. That's why I termed it mythological. I don't agree with the author's view (*Dream 2047*, January 2012) that it is improper to link purely scientific discovery with mythology. All religious beliefs are the result of our deeper thoughts/observations. Lord Rama and Hanumanji are mythological characters. They are believed to have lived about 10 million years ago. During this period humans separated from ape mans and both used to communicate in same language for quite some time even after their separation from each other. In "Recent developments in science and technology" in *Dream 2047*, December 2011, Biman Basu writes: "Prehistoric painters used pigments 100,000 years ago". It means during this period there existed a highly developed and technologically advanced society. But we don't have any evidence for this except the pigments.

Anirudh Kumar Satsangi
6, Dayalkunj, Dayalbagh, Agra-282005

[*Author's comment:* According to a paper published in the *Journal of Human Evolution* in 2008, the world's first known humans (*Homo sapiens sapiens*) appeared around 200,000 years ago. And it was not until about 150,000 years ago that articulated speech like that of modern humans was first spoken. Moreover, the fact that early humans could use a few natural pigments 100,000 years ago does in no way imply that "there existed a highly developed and technologically advanced society". - Biman Basu]

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Obituary

Dr. Ramesh Dutt Sharma (1939-2012)

Renowned Science Writer and former President of Indian Science Writer's Association (ISWA) Dr. Ramesh Dutt Sharma, 73, passed away on 6 February 2012 in Delhi.

Born on 15 February 1939 at Jalesar, Etah (Uttar Pradesh) Dr. Sharma got his early education in Jalesar town and did his B.SC and M.SC. (Botany) from Balwant Rajput College, Agra (Agra University). He did his Ph. D. from Garhwal University.

Dr. Sharma joined Commission for Scientific & Tenchnical Terminology in 1959 and contributed in coining botanical terminology in Hindi. He shifted to Pantnagar Agriculture University in 1968 as Associate Director where he launched popular agriculture monthly 'Kisan Bharti' and translation, original writing & production of agricultural text-books. Dr. Sharma joined ICAR, Delhi in 1970 and served this institution as Editor 'Kheti', Chief Editor and Director, Agriculture Information & Publications.

Dr. Sharma was visiting Editor at International Rice Research Institute, Manila, Phillipines for sometime and was also Advisor to Kisan Channel of IGNOU.

An expert in science communication, Dr. Sharma in his special style of writing contributed over 1,500 popular science articles, authored & translated about two dozen books, edited and produced about 200 books on Agriculture. He gave new direction to Hindi science writing through his distinct style of writing. He authored two books for Vigyan Prasar and contributed/ translated features for Dream 2047 since its inception.

He scripted, anchored, directed and produced over 500 each programmes for Akashvani and Doordarshan.

He was recipient of a number of awards including NCSTC National Award for science popularization, Indira Gandhi Award (INSA), Dr. Atma Ram Award, Bhartendu Harish Chandra Award, Prof. Jagdish Chandra Bose Award, Ch. Charan Singh Award for excellence in agricultural journalism.

In keeping with his last wish, his body was donated to Army College of Medical Sciences, Delhi Cantt. for organ donation and research.

National Workshop on Science Communication in Hindi through Digital Medium

Vigyan Prasar in collaboration with NCIDE (IGNOU) is organizing a two-day National Workshop on "Science Communication in Hindi through Digital Media" under its Rajbhasha Implementation programme. The basic objectives of the workshop include exploring the potential of digital media for science communication in Hindi, identifying the gap areas between the science communicators and the new technologies and to find out the possible solutions to promote the science communication in Hindi through digital medium. The sub-themes of the workshop are as follows:

1. Science Communication in Hindi through Digital Medium – Changing Scenario
2. ICT Enabled Science Communication in Hindi - Challenges and Prospects
3. Tools and Techniques for Science Communication in Hindi through Digital Medium
4. Innovative Media Trends of Science Popularisation in Hindi
5. Digital Translation for Science Popularisation and use of Acceptable Scientific Terms in Hindi

Scientists, science communicators, academics, technical managers, science activists engaged in above said areas are invited to attend the workshop and share their experiences about use of internet. In this regard interested participants are requested to send their presentations in the form of a paper on any of the topic relevant to the above mentioned sub-themes of the workshop. The language of paper will be Hindi and the paper (of around 2000-3000 words) neatly typed in krutidev 010 font should reach by 10 March, 2012 to Shri M. M. Gore, Member Secretary, Rajbhasha Committee, Vigyan Prasar, A-50, Institutional Area, Sector-62, Noida-201 309 (U.P.), India or by mail to mmgore@vigyanprasar.gov.in