**Editorial**

# Discovering India through science books

**Dr. Subodh Mahanti**

India is not simply a kind of anthropomorphic entity. Discovery of India (or knowing India) means knowing her landscape, her mountains, her rivers, her forests, her deserts, her cultural and intellectual heritage, her peoples, her religions, her art, her epics, languages spoken by its peoples, her literature, her folklores, her plants and animals, her ecosystem, her biodiversity, her system of governance, music and dances of her peoples, her churches, gurdwaras, masjids, and temples, her natural resources, her agricultural practices, her transport system, her communication system, her educational and research institutions, her achievements in science and technology, her heroes, struggles of her peoples for living with comfort, dignity and self-respect, aspirations of her peoples, and so on.

Discovery of India is a process or rather an unending process. There is so much to know and learn. Why does one need to discover or understand India? Is it just for the joy of it or just to satiate one's curiosity? Discovering or understanding India is extremely necessary if we are going make India's future secure and beautiful. But discovering India is not an easy task. Pandit Nehru realised this when he embarked on writing his famous book, *The Discovery of India*. Thus he wrote: "…I was again on a great voyage of discovery and the land of India and the people of India lay spread out before me. India with all her charm and variety began to grow upon me more and more, and yet the more I saw of her, the more I realised how very difficult it was for me or anyone else to grasp the ideas she had embodied."

Science books can help greatly in discovering India from many perspectives. India has a great past. She represents a very ancient civilisation. There is no doubt we should be proud of our glorious past. It can be a source of inspiration and guidance. But then it is also true that we should not be overpowered by the burden of past, the burden of both good and ill. The German philosopher Nietzsche wrote: "Not only the wisdom of centuries—also their madness breaketh out in us. Dangerous is it to be an heir." There is a need to bring out books for children presenting India's scientific heritage in the right perspective.

There cannot be a single book which will be enough for discovery of India. This means there is no one single ideal or perfect book. There are books and books on different facets of India. Books like *The Discovery of India* by Pt. Jawaharlal Nehru and *The Wonder that was India* by A. L. Basham attempted to cover all aspects of Indian life and thought. Such books are not only read in India but outside India and they get translated in many languages. Pt. Nehru's *The Discovery of India* was published in 1946. Basham's book dealt with the civilisational beginnings of India.

Scientific biographies and books on different facets of science and technology constitute an important class of books for discovering India. Today science and technology dominates every sphere of human activity. The future of India depends very much on how we develop science and technology for betterment of the society by solving the major problems faced by India. India is one of the ten most scientifically and technologically advanced countries in the world. But it is also true that a large section of Indians do not have access to food security, effective health care, and proper education.

Biographies and autobiographies of scientists can greatly inspire the young aspiring to embark on a scientific career. Such books tell them how the scientists became interested in science, who inspired them, what books they read, how they struggled against the adverse circumstances, and more importantly, how they continued to work without being disheartened by failures. In every field one needs a role model. There are a number of biographies and autobiographies of scientists. To name a few: *The man who knew infinity: A life of the genius Ramanujan* by Robert Kanigel; *Chandra: A biography of S. Chandrasekhar* by Kameshwar C. Wali; *The Life and Works of Sir Jagadis C. Bose* by P. Geddes; *Journey into light: Life and Science of Raman* by G. Venkataraman; *A Masterful spirit: Homi J. Bhabha (1909-1966)* by Indira Chowdhury and Ananya Dasgupta; *Lilavati's daughters: The women scientists of India*, edited by Rohini Godbole and Ram Ramaswamy; *Bright Sparks: Inspiring Indian scientists from the past* by Arvind Gupta; *Years of Pilgrimage : An autobiography* by Raja Ramanna; *The life and experiences of a Bengali chemist* by P. C. Ray; *Memoirs of Ruchi Ram Sahni: Pioneer of science popularisation in Punjab*, edited by N. K. Sehgal and S. Mahanti; *The fall of a sparrow* by Salim Ali; *The wings of fire* by A. P. J. Abdul Kalam, and *Climbing the limitless ladder: A life in science* by C. N. R. Rao. However, more such books

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# David Hilbert

## One of the Greatest Mathematicians in History

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"Hilbert was an excellent teacher and during his time at Götingen continued the tradition begun in the 19th century and built the university into an outstanding centre of mathematical research, which it remained until the dispersal of the intellectual community by the Nazis in 1933. Hilbert is generally considered one of the greatest mathematical of the 20th century and indeed of all time."

*A Dictionary of Scientists*, Oxford University Press, 1999

"It is difficult and often impossible to judge the value of a problem correctly in advance; for the final award depends upon the gain which science obtains from the problem. Nevertheless we can ask whether there are general criteria, which mark a good mathematical problem. An old French mathematician (Joseph-Louis Lagrange) said: 'A mathematical theory is not to be considered complete until you have made it so clear that you can explain it to the first man you meet on the street.' This clarity and ease of comprehension, here insisted on for a mathematical theory, I should still demand for a mathematical problem if it is to be perfect; for what is clear and easily comprehended attracts, the complicated repel us."

David Hilbert

"In the analysis of mathematical talent one has to differentiate between the ability to create new concepts that generate new types of thought structure and the gift for sensing deeper connections and underlying unity. In Hilbert's case, his greatness lies in an immensely powerful insight that penetrates into the depths of a question. All of his works contain examples from far-flung fields in which only he was able to discern an interrelatedness and connection with the problem at hand. From these, the synthesis, his work of art, was ultimately created. Insofar as the creation of new ideas is concerned, I would place Minkowski higher, and of the classical great ones, Gauss, Galois, and Riemann. But when it comes to penetrating insight, only a few of the very greatest were equal of Hilbert."

Otto Blumenthal, Hilbert's student

David Hilbert is regarded as one of the greatest mathematicians of all time. He gave geometry a mathematically rigorous foundation. He studied the properties of infinite dimensional space, known as Hilbert space, which is used in the mathematics of quantum theory. David Hilbert made significant contributions to many areas of mathematics and physics. Based on the year of publication of the results Hilbert's scientific research has been broadly divided into six periods:

1. Algebraic forms (from his joining of research to 1893)
2. Algebraic number theory (1894-1899)
3. Foundations of geometry (1899-1903)
4. Analysis (1904-1909)
5. Theoretical physics (1912-1914)
6. Foundations of mathematics (1918 to the end of his professional career)

Hilbert was a key figure in mathematical logic and the philosophy of mathematics. It was his experience with axiomatic method and his interest in consistency proofs which shaped his approach to mathematical logic and the foundations of mathematics. He was one of the major proponents of the formalist view. *A Dictionary of Scientists* of the Oxford University Press noted: "In mathematical logic and the philosophy of mathematics Hilbert is a key figure, being one of the major proponents of the formalist view, which he expounded with much greater precision than had his 19th century predecessors. This philosophical view of mathematics had a formative impact on the development of mathematical logic because of the central role it gave to the formalisation of mathematics into axiomatic systems and the study of their properties by mathematical means. Hilbert aimed at formalising as much of the mathematics as possible and finding consistency proofs for the resulting systems. It was soon shown by Kurt Goedel that Hilbert's program, as this proposal called, could not be carried out, at least in its original form; but it is nonetheless true that Goedel's own revolutionary work would have been inconceivable without Hilbert."


*David Hilbert*

He greatly influenced the course of mathematical research of the 20th century by compiling the list of the most important problems in mathematics in 1900. Hilbert was a great teacher. He influenced generations of mathematicians through his own teaching or through his students.

David Hilbert was born on 23 January 1862 in Koenigsberg in East Prussia (now Kalinigrad in Russia). His father Otto Hilbert was a judge in Koenigsberg. Hilbert's grandfather was also a judge. His mother Maria Therese Hilbert (*nee* Erdtmann) was the daughter of a merchant but she herself was interested in philosophy, astronomy and mathematics. Hilbert was influenced by his mother to study mathematics.

Hilbert attended the local gymnasium (preparatory school), Freidrichscolleg in Koenigsberg. The major emphasis of the Gymnasium was in classical languages. Hilbert did not display any kind of exceptional talent in school. At the last year of his school education Hilbert was transferred to Wilhelms-Gymnasium. After passing the examination for university admission in 1980, Hilbert joined where he studied from 1880 to 1884 for his PhD degree except for his second semester when he went to Heidelberg. He worked under the supervision of F. Lindermann. He received his PhD degree in 1985. His PhD thesis was on algebraic invariants. In Koenigsberg Hilbert came in contact with Hermann Minkowski and Adolf Hurwitz who greatly influenced him. After obtaining his PhD he visited Leipzig and Paris.

It may be noted here Immanuel Kant, the great German philosopher, also studied and taught in Koenigsberg. Kant proposed that mathematics is a form of knowledge which can be gained from pure reason alone. Kant's idea influenced Hilbert throughout his career.

In 1886, Hilbert joined the Koenigsberg University as Privatdozent (unsalaried lecturer) and worked there in that capacity till 1892 when he was appointed Professor extraordinary to replace Adolf Hurwitz. In 1895, he was given the prestigious chair of mathematics at the Götingen University, where he worked till his retirement in 1930.

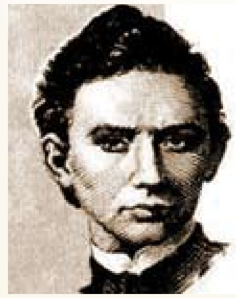
Hilbert's first major work in mathematics was on invariant theory. In 1888, he proved his famous basis theorem. Earlier Paul Albert Gordan (1837-1912) had proved the finite basis theorem for binary systems. However, Gordan had used a highly computational approach and his work could not be extended to systems with more than two variables, as computational difficulties became insurmountable. Hilbert after failing to extend Gordan's approach developed an altogether new approach. Hilbert's approach was highly abstract. Hilbert submitted the paper proving the finite basis theorem to *Mathematische Annalen*. The paper was referred to Gordan, being the expert on invariant theory for the journal, for reviewing. Gordan failed to recognise the importance of Hilbert's work. Thus, he sent his comments to the editor of the journal, Felix Christian Klein (1849-1925) expressing his apprehension on the suitability of the paper for publication in the journal. Hilbert had demanded that no changes be made in the paper. Klein realised the significance of Hilbert's paper and he published it without making any changes.

*Paul Albert Gordan*

*Felix Christian Klein*

Hilbert was one of those nineteenth-century mathematicians who had been reinterpreting the Euclidean geometry. Some of the important figures of this group other than Hilbert were Nikolai Ivanovich Lobachevski (1792-1856), Janos Bolyai (1802-1860) and Georg Friedrich Bernhard Riemann (1826-1866). The reasons behind such attempts were to open up new possibilities for analysis of problems in conventional geometry and analytic geometry which apparently appeared insoluble. But to Hilbert the goal seemed to be more profound. He visualised that redefining of Euclid's geometry would lead to a logical foundation upon which the entire structure of mathematics could be rested. It was Hilbert who exerted the greatest influence on the development of Euclidean geometry after Euclid himself. Euclid in his classic work on geometry, *Elements*, made many assumptions. Some of these assumptions were not even listed by Euclid. After making a critical study of Euclid's *Elements* Hilbert came up with the list of 21 axioms. Hilbert not only explained these axioms but proposed that they would be the basis for the further development of the subject. Thus Hilbert provided geometry with a formal axiomatic setting. He developed geometry from a much more rigorous set of axioms than those of Euclid. Hilbert's results were published in his classic work *Grundlagen der Geometrie* (*The Foundations of Geometry*, 1899). The book was considered so important that nine editions came out in the course of sixty years of its publication. This was part of Hilbert's attempt towards establishing a postulational basis for mathematics as a whole. Since Hilbert's first attempt the axiomatic approach has remained a permanent feature of mathematics.

*Nikolai Ivanovich Lobachevski*



*Janos Bolyai*

*Friedrich Bernhard Riemann*

Hilbert compiled the list of 23 unsolved problems which set the course of 20th century mathematical research. The list is regarded as the most successful and deeply considered compilation ever to be produced by an individual mathematician. He launched the problem set in a talk presented at the International Congress of Mathematics held in Paris in 1900. The title of his talk was "The Problems of Mathematics." At the Congress he described fewer than half the problems and in his subsequent publication he extended the list up to 23. The list later became known as '23 Problems of Hilbert'.

In the introduction to his speech Hilbert said: "Who among us would not be happy to lift the veil behind which is hidden the future; to gaze at the coming developments of our science and at the secrets of its development in the centuries to come? What will be the ends toward which the spirit of our future generations of mathematicians will end? What methods, what new facts will the new century reveal in the vast and rich field of mathematical thought?" In the course of his speech he further said: "The great importance of definite problems for the progress of mathematical science in general…is undeniable…[for] as long as a branch of knowledge supplies a surplus of such problems, it maintains its validity… every mathematician certainly shares…the conviction that every mathematical problem is necessarily capable of strict resolution…we hear within ourselves the constant cry: There is the problem, seek the solution. You can find it through pure thought…" (Quoted from J J O'Connor and E E Robertson http://www-history.mcs.st-andrews.ac.uk/Biographies/hilbert.html)

The 23 problems compiled by Hilbert are listed below:

1. Cantor's problem of the cardinal number of the continuum.

2. The compatibility of the arithmetical axioms.
3. The equality of the volumes of two tetrahedral of equal bases and equal altitudes.
4. Problems of the straight line as the shortest distance between two points.
5. Lie's concept of a continuous group of transformations without the assumption of the differentiability of the function defining the group.
6. Mathematical treatment of the axioms of physics.
7. Irrationality and transcendence of certain numbers.
8. Problems of prime numbers.
9. Proof of the most general law of reciprocity in any number field.
10. Determination of the solvability of a Diophantine equation.
11. Quadratic forms with any algebraic numerical coefficients.
12. Extension of Kronecker's theorem on Abelian fields to any algebraic realm of rationality.
13. Impossibility of solution of the general equation of the 7th degree by means of functions of only two arguments.
14. Proof of the finiteness of certain complete systems of functions.
15. Rigorous foundations of Schubert's enumerative calculus.
16. Problems of topology of algebraic curves and surfaces.
17. Expressions of definite forms by squares.
18. Building up space from congruent polyhedral.
19. Are the solutions of regular problems in the calculus of variations always necessarily analytic?
20. The general problem of boundary values.
21. Proof of the existence of linear differential equations having a prescribed monodromic group.
22. Uniformisation of analytic relations by means of automorphic functions.
23. Further development of the methods of the calculus of variations.

The mathematics created by solving some of the problems fully vindicated Hilbert's profound insight into mathematics. Commenting on the importance of the problems summed up by Hilbert, Paul Halmos wrote in 1958: "Mathematics of this century have been significantly fortunate in having a ready-made and inspiring list of problems to work on". The questions posed by Hilbert stirred the imagination of mathematicians because the questions were not only important for the development of mathematical ideas but they also posed real challenges before mathematicians. They were not easy to solve. In the process of solving each of the problems posed by Hilbert, mathematicians produced large body of new mathematics. Some of the problems listed by Hilbert were solved within a short time. Some were discussed throughout the 20th century. Some were dropped or restated because they were considered unsuitably open-ended. Some of the problems posed by Hilbert remain challenge for mathematicians. Mathematicians realised the problem 10 could not be solved; or in other words, it was not possible to derive the process sought by Hilbert for solving Diophantine equation. The problem 4 is too open-ended or vague. Problems 8 and 16 still remain as open questions.

In his *Grundlagen der Mathematik* published in two volumes (1934, 1939) Hilbert introduced his "proof theory" projected as a means for direct checking the consistence of mathematics.

The concept of Hilbert space has played a central role to the development of mathematical analysis. It is an abstract notion of great power and beauty. It assumes that the objects of primary interest in analysis namely functions enjoy geometrical properties which are in some ways analogous to the geometry of physical space. Hilbert space is truly fundamental mathematical structure which appears in widely diverse branches of pure as well as applied mathematics.

Hilbert received many awards. In 1910, Hilbert became only the second winner of the Bolyai Prize of the Hungarian Academy of Sciences. It was the recognition of the fact that Hilbert was one of the leading mathematicians of his time. The first winner of the prize in 1905 was Henri Poincare, the most prolific mathematician of the 19th century.

Hilbert died on 14 February 1943.

It may not be possible for everyone to appreciate the work of Hilbert but everyone can be inspired by Hilbert's spirit which can be summarised as follows: There is a problem, one should seek its solution and one can solve it. The problem can be in any field.

### Keeping the Hilbert s spirit alive

The Clay Mathematics Institute, a Cambridge, Massachusetts-based private initiative of the Clay Foundation has identified the seven important problems in mathematics. These problems, which are given below, are called Seven Millennium Problems. The CMI has announced that 1 million US dollars will be given for solving each of the millennium problems.

1. P versus NP
2. The Hodge conjecture
3. The Poincare conjecture
4. The Riemann hypothesis
5. Yang-Mills existence and mass gap
6. Navier-Stokes existence and smoothness
7. The Birch and Swinnerton-Dyer conjecture.

Only one of the seven problems, the Poincare conjecture, has been solved so far. The problem was solved by G. Perelman of Saint Petersburg and he was given the $ 1 million prize of the Clay Foundation in 2010.

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3. *A Dictionary of Scientists*, Oxford University Press, 1999.
4. Available sources on the Internet.


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

# A Primer on Prime Numbers

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Mathematicians have been asking questions about prime numbers for more than twenty-five centuries, and every answer seems to generate a flurry of new questions. Throughout the history of prime number all gifted mathematicians–from Pythagoras and Euclid to Fermat, Gauss, and twentieth century mathematicians including Ramanujan figure prominently.

A prime number (or a prime) is an integer greater than 1 that can be divided only by itself and 1. A natural number greater than 1 that is not a prime number is called a composite number. For example 5 is a prime, as it is divisible by only 1 and 5, whereas 6 is composite, because it has the divisors 2 and 3 in addition to 1 and 6. This division between prime and composite numbers turnsout to be one of the cornerstones of mathematics, and is a characteristic which is used in mathematical proofs over and over.

There are an infinite number of prime numbers. Another way of saying this is that the sequence 2, 3, 5, 7, 11, 13, ...of prime numbers never ends. 1 is not a prime number. 2 is the first prime number and the only even prime number; all other primes are odd.

All positive integers are called natural numbers. In this definition of natural numbers, zero is not included. However, during 19th century natural numbers weredefined as non-negative integers (0, 1, 2, 3,....). All the natural numbers in the number sequence divide themselves into prime numbers and nonprime numbers (or composite numbers).

## Prime factors and fundamental theorem of arithmetic

To understand the importance of the characteristic of being either prime or composite, we must look at how composite numbers factorise. If we factorise a composite number into two smaller numbers, then it is to be seen whether these two numbers are themselves primes or composites. For example, 6 factorises into 2x3. Both 2 and 3 are prime numbers. Eighteen factorises into 2x9. Here the 2 is a prime but 9 is not. However, 9 factorises into 3x3 and 3 is a prime. Hence 18 can be written as 18 = 2x3x3. Any composite number, no matter how large, can be factorised into two smaller numbers. We then ask whether each of the smaller factors isa prime or composite.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |

*Primes (marked red) in first hundred*

If either one is composite, we factorise it again. The process continues till all the factors are primes. Hence, every composite number can be written as a product of prime numbers. We can therefore say that all the natural numbers can be represented as primes or product of primes. This in itself is interesting and leads to a fascinating conclusion. When a composite number is factorised into primes, those primes are unique to that number. For example, we can factorisethe number 30 into 2x3x5. No other set of primes, when multiplied together, will yield 30. This leads to one of the building blocks of mathematics, namely, Every whole number greater than 1 can be expressed as a product of prime numbers in one and only one way, which has come to be known as the fundamental theory of arithmetic.

It is interesting to observe that if 1 is considered a prime, then this rule breaks! Because 30 = 2x3x5 and also 30 = 1x2x3x5. Hence factorisation of 30 will not be unique. Therefore 1 is not a prime number.

## Discover new prime number pattern: take the challenge

Prime numbers are randomly distributed among the natural numbers, without any apparent pattern. However, the global distribution of primes reveals a remarkably smooth regularity. This is best illustrated by the words of Professor Robert Charles Vaughan of Pennsylvania State University, in one of his research papers(February 1990):"It is evident that the prime numbers are randomly distributed but, unfortunately, we don't know what 'random' means."

Mathematicians have studied prime numbers for centuries, but prime numbers have never failed to intrigue them with unexpected and amazing results. Even today, it is still possible to discover unnoticed hints of statistical regularity in a prime number sequence, without being an expert in number theory.

Carefully look at the following table, where numbers are arranged in six columns, beginning with 1.

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 | Column 6 |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | 32 | 33 | 34 | 35 | 36 |
| 37 | 38 | 39 | 40 | 41 | 42 |

Notice that all the primes, except 2 and 3, are either in column 1 or column 5. You can try to expand the table and you will note that all prime numbers, except 2 and 3, will appear either in column 1 or in column 5. However, distribution of primes within column 1 and 5 is random.

## History of primes

It is believed that around 1650 BC, ancient Egyptians knew about prime numbers. However, the earliest surviving records of the explicit study of prime numbers come from the Ancient Greeks. Euclid's *Elements* (circa 300 BC) contain important theorems about primes, including the fundamental theorem of arithmetic.

*Pierre de Fermat*

After the Greeks, major documentary evidence of the study of prime numbers appeared in the 17th century. In 1640, French lawyer and an amateur mathematician Pierre de Fermat (1601-1665), while researching perfect numbers came up with a formula to generate prime numbers. Fermat conjectured that all numbers of the form ( $2^{2^n}+1$), where *n* is any natural number, are prime. Fermat verified this up to *n* = 4 (or $2^{16}$ + 1). However, the very next Fermat number $2^{32}$ + 1 is a composite (one of its prime factors is 641). In fact no further Fermat number is known to be a prime.

German mathematician and physical scientist Johann Carl Friedrich Gauss (1777 – 1855) did significant work on prime numbers. Gauss spent hours trying to figure out some pattern or regularity in the distribution of prime numbers. Initially he confirmed the findings of the ancient Greeks that there appeared to be no pattern. However, later he discovered that if numbers are grouped according to powers of 10 (that is: 1-10, 1-100, 1-1000, etc) and then if one picks a number at random from within each range, the probability of it being a prime has some regular pattern. It is shown in the following table:

*Johann Carl Friedrich Gauss*

| Number (up to...) | No. of primes | Probability |
|---|---|---|
| 10 | 4 | 1:2.5 |
| 100 | 25 | 1:4 |
| 1,000 | 168 | 1:7 |
| 10,000 | 1,229 | 1:9 |
| 100,000 | 9,592 | 1:11 |

In this way a 'regularity appeared out of the mist of disorder'. Each time a larger number group was considered, the probability of getting a prime number went down. That is, as the numbers got bigger, the prime numbers thinned out according to a predictable pattern.This eventually led to the prime number theorem (PNT) that describes the asymptotic distribution of the prime numbers. The prime number theorem gives a general description of how the primes are distributed amongst the positive integers. The prime number theorem states that the number of primes less than *n* is approximately *n* divided by the logarithm of *n*.

## Unsolved mysteries

Most of the unsolved problems in mathematics are related to prime numbers. A few are mentioned here.

## Mersenne primes

French philosopher and mathematician Marin Mersenne(1588–1648)showed that all number in the form ($2^p - 1$) are prime numbers, where '*p*' is a prime. They are called Mersenne primes in his honour. For example, if p = 7 (a prime), then $2^7$– 1 = (128 – 1) = 127 is a prime number. Many fundamental questions about Mersenne primes remain unresolved. It is not even known whether the set of Mersenne primes is finite.

The largest known prime has almost always been a Mersenne prime. Largest known Mersenne prime is $2^{43112609}$ - 1which has12,978,189 digits.

## Twin prime

A twin prime is a prime number that differs from another prime number by two. Except for the pair (2, 3), this is the smallest possible difference between two primes. Some examples of twin prime pairs are (3, 5), (5, 7), (11, 13), (17, 19), (29, 31) and (41, 43). The question of whether there exist infinitely many twin primes has been one of the great open questions in number theory for many years. This is the content of the twin prime conjecture, which states that there are infinitely many primes p such that p + 2 is also prime. Since every third odd number is divisible by 3, no three successive odd numbers can be prime unless one of them is 3; thus 5 is the only prime which is part of two pairs (3,5) and (5,7).

## Palindromic prime

A palindromic prime is a prime number that is also a palindromic number. The first few palindromic primes are: 2, 3, 5, 7, 11, 101, 131, 151, 181, 191, 313, 353, 373, 383, 727, 757, 787, 797, 919, 929,….Except for 11, all palindromic primes have an odd number of digits. It is not known if there are infinitely many palindromic primes.

## Riemann hypothesis

German mathematician Georg Friedrich Bernhard Riemann (1826–1866) made many important contributions to modern analytic number theory. He introduced the *Riemann zeta function* and established its importance for understanding the distribution of prime numbers. He made a series of conjectures about properties of the zeta function, one of which is the well-known *Riemann hypothesis*. The Riemann hypothesis implies predictability in the distribution of prime numbers. Along with suitable generalisations, it is considered by some mathematicians to be the most important unresolved problem in pure mathematics.

## Finding primes

Despite efforts by all leading mathematicians, there is no formula for computing the $n^{th}$ prime. But if we know the value of a prime, then can we calculate the very next prime? In other words, if $P_n$ is the $n^{th}$ prime, then where is the next prime $P_{n+1}$? In 1845 mathematician Joseph Bertrand conjectured that if *n*>= 2, then at least one prime exists between *n* and 2n. For example, if *n* = 4, then there will be a prime between 4 and 8 and this is : 7. However, when n is very large, then the range becomes even larger.

French mathematician Joseph L. F. Bertrand (1822 – 1900) conjectured that if n t2 then $P_n + P_{n+1} > P_{n+2}$. For example, 5 + 7 = 12, which is greater than the next prime 11.

Also $P_m \times P_n > P_{m+n}$, or product of two primes $P_m$ and $P_n$ is greater than the $(m+n)^{th}$ prime. Thus,7 is the fourth prime and 11 is the fifth prime. The relation says that 7x11 or 77 is greater than the $(4+5)^{th}$ or 9th prime. The ninth prime is 23, which is less than 77.

Many formulae do exist that produces nothing but prime numbers. However, these formulae do not produce each successive prime nor do they predict the next prime in sequence.

## Conclusion

One of the intriguing aspects of the primes is that there is an infinite number of primes and they seem to be scattered randomly among the integers, with no apparent pattern governing their distribution. The list of primes never ends. In fact, all attempts to find a formula that will produce only primes have so far failed. However, the distribution of primes and the statistical behaviour of primes on the whole, can be modelled.

Primes, once the exclusive domain of pure mathematics, have recently found an unexpected ally in matters of computer security. Based on the difficulty of factorising a product of two very large primes, *public-key cryptography* was invented.

Since 1951 all the largest known primes have been found by computers. The search for ever larger primes has generated interest outside mathematical circles. The Great Internet Mersenne Prime Search and other distributed computing projects to find large primes have become popular, while mathematicians continue to search hidden treasures in the infinite distribution of primes.

## Sources:

Ian Stewart, *Cabinet of Mathematical Curiosities*

Calvin C. Clawson, *The beauty and magic of numbers*

An excellent account on prime numbers may be found at: http://en.wikipedia.org/wiki/Prime_number

## Indian Wonder Girl of IYC 2011

I am an Assistant Engineer in Public Health Engineering Department, Govt. of Rajasthan and I liked your editorial in Dream 2047, February 2012 issue titled 'Taking ahead message of the IYC 2011'. I would like to share with you an interesting piece of news about IYC 2011.

My daughter Poorvie Choudhary is 10 years old and she is studying in class V at Rajmata Krishna Kumari Girls' Public School, Jodhpur. Poorvie has a sharp memory and she has not only memorised the Periodic Table of chemical elements but also made a world record by reciting it in the fastest time. On 13 October 2011 she broke the existing world record of 36.23 sec. of reciting the Periodic Table of 118 elements by doing it in 31.43 sec. Since then she has continuously improved her time and her current world record is just 9.38 sec to recite the symbols of all the 118 elements.

Poorvie is also the youngest to write all the 118 symbols in a blank Periodic Table in a time of 2 min 43.13 seconds. Poorvie made these world records in the International Year of Chemistry (IYC) 2011, as declared by the UNESCO and IUPAC. Her records are also available on the official website of IYC 2011 at the following link: http://www.chemistry2011.org/participate/activities/show?id=1663.

Poorvie's world record has been referred as one of the best achievements of International Year of Chemistry 2011 by Geoffrey Lean, senior UK journalist in his article in *The Telegraph*, UK, which is available at the following link:http://www.telegraph.co.uk/earth/countryside/8985039/Human-bodies-contain-too-many-damaging-chemicals.html.

Poorvie was felicitated by the District Collector Jodhpur on Republic Day 2012 for her world record.

I am sure your readers would be happy to learn about Poorvie's achievements.

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Continued from page 35

## (Editorial - Discovering India through science books)

need to written, particularly autobiographies and memoirs of contemporary scientists. Such books should be brought out in local languages and in a form which is attractive to children.

India manifests in seemingly infinite diversity. However, in the midst of such tremendous diversity, oneness of India is clearly discernible. There are many common threads underlining this oneness. This spirit should be inculcated among children. Books on local flora and fauna and natural resources should be brought out for children highlighting the importance of their conservation in local languages.

Good books on questions and answers in science can discover talent in young Indians. There are many books on questions and answers but they are mostly designed to make the students quiz masters. These books do not evoke curiosity in students to ask more questions or think differently. They do not answer the questions that arise in their minds from their everyday experience. There should be appropriate books on questions and answers. Professor Yash Pal's book (written with Rahul Pal), *Discovered questions* is an important step in this direction.

Discovery of India through science books should make one also familiar with the problems faced by the country and how they could be solved by the applications of science and technology. True development of science and technology for societal development will take place only if the scientific attitude or scientific temper, as Pt. Nehru called it, is spread to all spheres of the society including politics. Mere acquiring scientific knowledge is not enough for developing scientific temper. It is the questioning spirit which lies at the root of scientific temper. Weighing all possible evidences is an important attribute of scientific temper. It teaches us to think and act rationally. India has a long tradition of rational thinking. India is also the only country where the inculcation of scientific temper is a constitutional duty of every citizen. Enough books need to be brought out on scientific temper particularly for children.

# Elephant mystery solved

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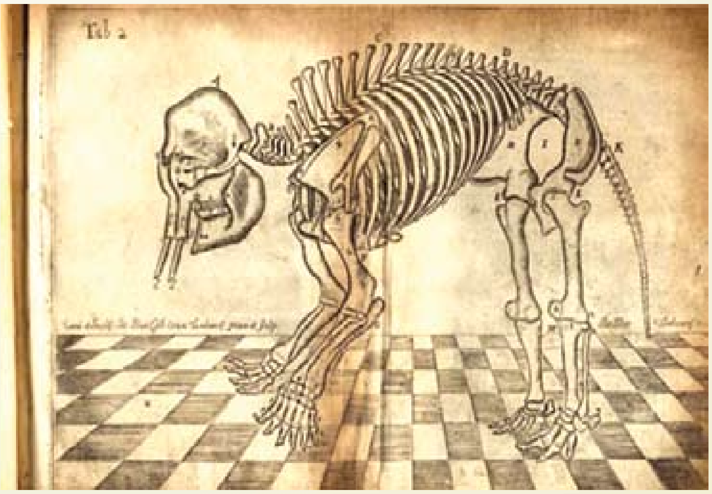
April 1706, a caravan of animals was approaching Dundee, a small town in Scotland. Camels, horses, bulls and a few elephants adorned the caravan. Elephants were a curiosity and all along the way the village populace gathered to look at the wonder; who wouldn't? Just as the caravan was about to reach its destination, a wagon turned, pushing a female elephant aside. The elephant stumbled and fell over a ditch, injuring itself. As the injured elephant could not be raised to her feet, it was abandoned. The deserted animal died in in a few days and the locals pounced upon the carcass to collect whatever souvenir that they could lay hands on.

On hearing this Dr Patrick Blair, a Scottish doctor, rushed to the spot and embarked on a mission to become the first man in Britain to dissect an elephant. He employed Gilbert Orum, surgeons' assistant and skilled copper engraver, to help him. After the dissection, the skeleton was reassembled as the centre-piece for a new 'Publick Hall of Rarities' in the town. The specimen is still on display in the museum. Then Blair published his findings, first ever anatomical account of an elephant, for the Royal Society in London, hoping to make his name as a great scientist.

As Blair dissected the colossal animal, buried beneath the leathery skin of an elephant's foot he found something unexpected. Though on a casual glance the leg of the elephant seems to be flat as a board, actually it stands on tip-toe, like a horse or a dog. That is, the leg of an elephant could be compared to a high-heeled platform shoe. Just as the extra rubber or leather is added to create the elevation in the platform shoe, in elephants it is a large pad of fat that gives the animal a flat-footed appearance, hiding the heel completely. This was not the only amazing fact Blair culled out; he also found that there were six toes on the front foot; and possibly on both feet. Many birds have three toes in their leg; and all animals have just five. Is the elephant distinct in having six toes? Three hundred years ago, this claim by Dr Blair, that elephants had six toes instead of the usual five, set off a debate about whether an extra digit was really possible.

Intrigued by the Blair's claim, since then anatomist have been dissecting elephants to see if they really have six toes instead of usual five. Modern anatomists scoffed at the idea, insisting instead that the extra toe was perhaps really just a big lump of cartilage. Indeed we can clearly see five and not six toe nails. However, a strange toe-like rod of cartilage called the prepollex, resembling the sixth toe of Blair, was occasionally noted in the fore and hind feet of elephants, keeping the controversy fresh and brewing.

Almost exactly 300 years later, scientists have solved this mystery. A team lead by Professor John R. Hutchinson, an evolutionary bio-mechanist at the Royal Veterinary College in London, has confirmed that the enigmatic lumps are not real toes but are more like a panda's fake thumb. Nonetheless it functions like a real toe and helps support the pachyderm's mighty girth (*Science* 23 December 2011 | DOI: 10.1126/science.1211437).



*An image from Patrick Blair's Osteographica Elephantina (1710), showing a six-toed elephant*

Hutchinson had a rather bizarre hobby. For years he collected and preserved elephant feet, with flesh and all from animals that died in zoos. His zookeeper friends across the globe send him amputated legs from newborn calves to fully matured animals in their 50s. The collection came in handy when he subjected these specimens to analysis using the computed tomography (CT) scans, which use x-rays to image tissues in slices to get 3-D pictures.

Though the real toes of elephants are not visible, as they are embedded inside the fatty pad, the first interesting feature that came to light was that elephants walk on tiptoe, with the instep and heel off the ground. Like the ballet dancer who swirls on the tip of the toe, elephants walk with their toes concealed in the fatty tissue that makes up its column-like leg.

Secondly, as he compared the anatomy of the elephant feet from infant to mature state, he found a very strange pattern. A rod of cartilage, also known as sesamoid that was habitually dismissed as a minor curiosity by previous studies, indeed often became denser, like bone, as the elephants got older. Fully matured cartilage rod was about 15 centimetres long and 6 centimetres wide that gave it an appearance of an extra toe. In humans too the knee cap transforms from cartilage to bone-like as we grow older, and in the Panda it becomes an extra toe acting as a thumb that helps it hold bamboo. While in most elephants such growth was clearly seen, in some the bony structure was absent. This is not so unusual, as sesamoid bones in other species tend to be highly variable.

Thirdly, Hutchinson found, at the first glance, in the CT scan pictures the sixth false toe to be too high off the ground to bear weight or do much good. But by taking CT scan of some of the collected elephant feet loaded with weight, he showed that the sixth toe actually acts as a strut that stiffens the back of the fat pad. This also explains why the toe gets stronger as the animal gets older and heavier.

Hutchinson thinks that researchers who dissected elephants in the past missed the sixth toe because it is so deeply embedded in the fat pad. This unique structure is so hidden in a web of fibres, tendons and muscles that unless the anatomist cuts through carefully he would miss it as just another odd piece of cartilage. This is why the extra digit never appears in museum specimens — curators usually throw it away.

Hutchinson also took the next step; he looked at the fossils of the elephant ancestors to find out when the sixth toe evolved. Fossils of elephant ancestors that lived 50 million years ago did not exhibit the sixth toe. However this unique anatomical structure appears from fossils of elephant ancestors from around 40 million years ago. From this Hutchinson postulates that older ancestors of elephants that lived mostly in water and were comparatively smaller did not need the extra toe-like structure to balance itself. Nevertheless about 40 million years ago elephants began to get bigger and were largely land based. Hutchinson says that their feet were evolving to better support their weight, with an expansion of the fat pads.

# The Ramanujan Number: 1729

The story goes like this. Srinivasa Ramanujan used to remain unwell most of the time during his stay in England. His mentor G. H. Hardy was not only instrumental in presenting his genius to the world but also take care of his health when he was abroad. Almost every day, he would scold Ramanujan for not taking his food, medicine, etc., regularly. One such day when Ramanujan was in hospital Hardy came to meet him but was looking quite morose, whereas Ramanujan was quite cheerful. Ramanjan asked his mentor, "Why are you looking so much upset, I am rather fine today".

Hardy replied, "You are a wizard of numbers, but today I came in a taxi and I found its number to be very uninteresting."

"What was that number?" Ramanujan asked.

Hardy replied, "It was 1729."

Pat came the reply from Ramanujan. "There perhaps cannot be a more interesting number than 1729. There are very few numbers which can be expressed as the sum of two cubes in two different ways and 1729 is the least among them."

Indeed the number 1729 is very interesting. A few unique characteristics of this number are presented below:

1) It is the least number which can be expressed as the sum of two cubes in two different ways:

$12^3 + 1^3 = 1728 + 1 = 1729$

$10^3 + 9^3 = 1000 + 729 = 1729$

2) However, if we consider the negative integers also, then '91' is the least number which fulfills this condition.

$4^3 + 3^3 = 64 + 27 = 91$

$6^3 + (-5)^3 = 216 + (-125) = 216 - 125 = 91$

Incidentally, '91' is a factor of 1729.

3) The other numbers which can be expressed as the sum of two cubes in two different ways are the following:

$4104 = 16^3 + 2^3 = 15^3 + 9^3$

$13832 = 24^3 + 2^3 = 20^3 + 18^3$

$40033 = 34^3 + 9^3 = 33^3 + 16^3$

$64232 = 39^3 + 17^3 = 36^3 + 26^3$

$110808 = 48^3 + 6^3 = 45^3 + 27^3$

$149389 = 53^3 + 8^3 = 50^3 + 29^3$

$171288 = 55^3 + 17^3 = 54^3 + 24^3$

$842751 = 94^3 + 23^3 = 84^3 + 63^3$

$2418271 = 134^3 + 23^3 = 116^3 + 95^3$

$7620661 = 174^3 + 133^3 = 196^3 + 45^3$

4) The product of all factors of 1729, including the number itself, is equal to the 4th power of 1729.

1 u7 u13 u19 u91 u133 u247 u1729 = $1729^4$

5) The sum of all factors of 1729, except the number itself, can be expressed as the difference of two cubes.

$1 + 7 + 13 + 19 + 91 + 133 + 247 = 8^3 - 1^3$

6) 1729 can be expressed as the difference of two squares in four different ways:

1729 = 1729 u1 = (865 + 864) (865  864) = $865^2 - 864^2$

= 247 u7 = (127 + 120) (127 – 120) = $127^2 - 120^2$

= 133 u13 = (73 + 60) (73 – 60) = $73^2 - 60^2$

= 91 u19 = (55 + 36) (55– 36) = $55^2 - 36^2$

7) Harshad Number:

If the sum of the digits which constitute a natural number is a factor of the number itself then the number is called a Harshad Number. 1729 is a Harshad Number.

1 + 7 + 2 + 9 = 19, which is a factor of 1729

8) Carmichael Number:

A non-prime natural number 'n' is called a Carmichael Number if

i) 'n' is not a perfect square

ii) The prime number 'p' is a factor of 'n', then (p-1) will be a factor of (n-1).

The first three Carmichael Numbers are respectively 561, 1105, and 1729.

561 = 3 u11 u17 ; 2, 10 and 16 are all factors of 560

1105 = 5 u13 u17 ; 4, 12 and 16 are all factors of 1104

1729 = 7 u13 u19 ; 6, 12 and 18 are all factors of 1728

9) 1, 81, 1458 & 1729 are again a peculiar class of numbers. If the digits constituting the said numbers are added and the sum is expressed in the reverse order, then the product of this sum and its reverse order generates the number concerned.

For example,

(1) o 1 u1 = 1

(81) o 8 + 1 = 9; 9 u9 = 81

(1458) o 1 + 4 + 5 + 8 = 18; 18 u81 = 1458

(1729) o 1 + 7 + 2 + 9 = 19; 19 u91 = 1729

10) 'e' is a transcendental number. So it is a non-recurring and non-terminating decimal.

Incidentally the 1729th place onward up to the tenth place, both inclusive, are the numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 0.

1729th place marks the first occurrence of such a sequence.

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# Garlic and Onion - Herbs for health

Dr. Sindhu

Dr. Satyakumar Vidyashankar

## Historical perspective

The use of garlic and onion is recorded by the great herbalists and physicians of the ancient world. "Garlic has powerful properties, and is of great benefit against changes of water and of residence . . ," wrote Pliny the Elder, the first century Roman naturalist (AD 23-79). He recommended garlic as an antidote for the poisonous bites of shrews and snakes, as well as poisoning from aconite and henbane. Pliny noted its use in the treatment of asthma, as a cough suppressant, and to expel intestinal parasites. He regarded the freshly crushed seeds of coriander, mixed with garlic in wine, as an aphrodisiac. While excessive use of garlic may dull the sight, causing flatulence, injure the stomach, and cause thirst. The herb was also surrounded in superstition. In some parts of Europe, men running a race would chew a small piece of the bulb, because it was believed that this would prevent competitors from getting ahead of them. William Coles in his *Art of Simpling* (1657) wrote, "Cocks having eaten garlic, are most stout to fight and so are horses." Through the ages, herbalists have considered garlic a good carminative for digestive problems and an excellent treatment for diarrhoea and a treatment for bacterial, fungal, and viral infections. In many ethnic populations garlic has been used to treat intestinal parasites. In the First World War, garlic was widely used as an antiseptic to treat the warriors. In short, garlic has been used for about every human ailment. Modern research on garlic and onion has focused on their value as a "preventer of disease."

The pharmacological effects of spices and their possible health benefits have been studied for centuries. Spices are used for medicinal purposes as well as for added flavour and aroma in many food dishes worldwide. Spices are therefore of considerable economic importance. Garlic and onion accounted for more than 4 billion US dollars worth of India's export during 2010-2011 (Source: Department of Commerce, Government of India, Export Import Data Bank). The potential medical benefits of spices include possible roles in lowering the risk for atherosclerosis, cardiovascular disease, cancer, gastroenterological disorders and diabetes. While spices have been used for their presumed health benefits for thousands of years, new medical research is now uncovering the underlying physiological and molecular mechanisms of their action as well as providing some scientific evidence of their effectiveness. There is promising evidence for antioxidant, anti-inflammatory, and antibacterial properties of garlic and onion, however, limitation at this time is that the doses used in many *in vitro* studies exceed those typically consumed by humans on a daily basis. On the other hand, epidemiological studies show an inverse correlation between garlic consumption and the risk for cardiovascular disease. Optimal doses for maximal benefit to human health, while avoiding toxic effects such as anaemia, remain to be defined and controlled human trials are needed to address this issue.

## Organosulphur compounds in garlic and onion

Garlic and onion are both belong to the *Allium* family and contain organosulphur compounds with antioxidant, anti-inflammatory, and antimicrobial properties. Garlic, botanically known as *Allium sativum*, is a widely studied spice with many purported benefits and a long medicinal history dating back to Aristotle, Hippocrates, and Aristophane. Garlic typically contains three times greater levels of organosulphur compounds than onion. After chopping or crushing, the enzyme allinase converts a compound called alliin in garlic to allicin. The latter compound is thought to be responsible for many of garlic's medicinal effects, but garlic has also been shown to be metabolised to a number of additional organosulphur compounds. The effect of cooking on garlic is controversial. It is reported that boiling increased garlic's overall antioxidant activity and other health beneficial effects. On the other hand, it is believed that some garlic antioxidants are thermally unstable and allinase is inactivated by heat, thus preventing allicin formation.

Onion, botanically known as *Allium cepa*, is another herb with medicinal properties as well as uses for flavour and aroma. A major active ingredient of onion is a substance called S-propenylcysteine sulphoxide. Onion possesses antioxidant and antibacterial properties, but the antioxidant activity is less than that of garlic. The antioxidant activity of onion is reduced after cooking, and onion is thus most effective in its raw form. Interestingly, different types of onions were found to vary in their properties, with highest total antioxidant activities as well as greatest *in vitro* tumor cell inhibition seen in the onion variety Western Yellow.

## Role of garlic and onion as antioxidants

Antioxidants are compounds able to slow down, stop, or reverse oxidation processes by scavenging oxidising agents, such as reactive oxygen species (ROS), and recycling oxidised lipids (fats), proteins, and nucleic acids. When present in excess amounts, ROS increases the risk of atherosclerosis and chronic diseases. Oxidation of lipids is known to decrease the survival of red blood cells. Allicin has been shown to act as an antioxidant by scavenging ROS and preventing lipid oxidation. Similar results were reported for garlic and onion extracts.

In a study, rats were fed with a high-fat diet with or without garlic, and blood levels of triglycerides and thiols (sulphur-containing compound similar to alcohols) such as glutathione were assessed. Food intake *per se* was not affected by garlic. The high-fat diet increased the levels of blood triglycerides, decreased the levels of thiols such as glutathione, and increased lipid oxidation. All of these adverse effects of the high-fat diet were effectively reduced by regular addition of garlic to the diet, thus presumably reducing the risk of atherosclerosis. When garlic was added to the high-fat diet, total internally produced thiols increased and the level of an endogenous antioxidant enzyme, catalase, which is depleted under oxidative stress, was also increased. The sulphur compounds in garlic are thus able to protect the amount of thiol produced internally (by converting thiols that become oxidised back into reduced thiols). More studies in similar lines support the effect of garlic in improving cardiovascular health, e.g., via decrease in platelet aggregation, a lowering of blood pressure and cholesterol levels, and inhibition of several steps in the inflammation process.

## $QWLLQDPPDWRUHIIHFWV of garlic and onion

Chronic over-production of enzymes known as cyclooxygenase (COX) or lipoxygenase (LOX) causes excess inflammation and contributes to chronic pro-inflammatory diseases such as cardiovascular disease, diabetes, and others. The messengers produced by LOX can also either stimulate or prevent programmed cell death. Excessive cell death is involved in neurodegenerative disease (involving loss of function and death of neurons), while insufficient cell death can lead to cancer. In addition to limiting how much of these inflammatory enzymes are manufactured, spices can also dampen the actual activity of existing the pool of inflammatory enzymes such as COX and LOX. Certain chemicals found in onion were shown to inhibit COX and LOX activity as well as blood platelet aggregation. It was also shown that onion extract can decrease the onset and development of tumours as well as have anti-asthmatic effects (the latter again via COX inhibition).

## Antimicrobial effects of garlic and onion

In addition to being antioxidants and anti-inflammatory agents, garlic and onion also have antibacterial/antimicrobial properties. The antibacterial properties of garlic can be eliminated by inhibition of the allinase enzyme and prevention of allicin formation. The antibacterial effect garlic apparently results from interaction of sulphur compounds, like allicin, with sulphur (thiol) groups of microbial enzymes (such as trypsin and other proteases), leading to an inhibition of microbial growth. Many bacterial strains,

both gram-positive and gram-negative, can be inhibited by garlic, and some strains were inhibited much more strongly by allicin or garlic extract compared to antibiotics. The bacterial strain *Staphylococcus aureus* causes pus-producing infections, such as boils, as well as pneumonia and urinary tract infections. Cultures of this strain, as well as *Salmonella enteritidis*, the bacterium responsible for salmonella food poisoning, and several fungi are effectively inhibited by garlic and onion oil or extracts. Other microbes inhibited by garlic include *Bacillus subtilis*, a gram-positive bacterium found in soil; *Escherichia coli*, a common toxin-producing, food-borne bacterium; and *Saccharomyces cerevisiae*, a yeast species. Remarkably, mouthwash containing garlic significantly reduced total salivary bacteria, including *Porphyromonas gingivalis*, the bacterium that causes gingivitis. Onions possess antibacterial properties as well. Although less research is available on the antibacterial activity of onion, it is suggested that S-propenylcysteine sulphoxide is the compound that inhibits antibacterial metabolism by the same mechanism as garlic. Onion extract, the activity of which remained stable for 48 h, inhibited *Streptococcus mutans*, a bacterium that causes strep throat, tonsillitis, bacterial pneumonia, as well as other diseases.

## Adverse effects of garlic and onion

Excessive consumption of concentrated formulations of garlic can lead to adverse effects on health, such as anaemia, weight loss, and toxicity to the heart, liver, and kidney as well as breaks in chromosomes. Doses of 4 ml/kg, for raw garlic juice, or of 100 mg/kg, for garlic oil, were lethal to rats.

Problems can arise from high doses of onion as well. One study showed that high doses (500 mg/kg) given orally caused lung and tissue damage in rats. Contact dermatitis, irritation of the skin due to allergens, could be induced with garlic. The specific allergens have not yet been identified, but both *Allium* spices can cause burns after external application.

## Conclusions

Garlic and onion each possess antioxidant, anti-inflammatory, and antibacterial properties. The effectiveness of these spices in reducing pro-inflammatory diseases is rooted in their nature as modulators of metabolism, for example as COX and LOX inhibitors. While the available evidence is encouraging, controlled human trails are needed to establish the effectiveness of these spices in disease prevention. Many of the available studies utilised relatively high doses of the effective compounds in garlic and onion, and it remains to be seen whether a moderate level of consumption, that avoids the toxic effects of excessive doses, is effective. Until such trials are available, it seems safe to conclude that garlic and onion should be included in the human diet as whole foods and spices, while high-dose extracts should be used with caution under strict medical supervision.

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# Dental Implants

## Rescuing Your Good Health and Smile from Tooth Loss

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Twenty-year-old Aditya – a handsome young man and a heart-throb of many at the university – was simply devastated. The other day, standing up to the fastest bowler of his college team during a practice game, he found two of his upper front teeth knocked out by a ball that suddenly jumped up from a good length spot. With blood oozing out of his mouth, he had forlornly asked the team doctor, "Would I ever be able to bite an apple again, doc? Or smile?" His spirits nosedived when the dentist he went to, gave him a partial denture. The contraption kept falling out. He could not even talk. Aditya was in utter despair.

"The dentist did tell me that he could fix a permanent dental bridge, if I so wished. But that would have required grinding the two adjoining good teeth. I did not like the idea, since I felt that would have weakened them," he says.

It was then that a friend told him about tooth implants. Aditya was quick to take the option. Now six-months later, he says, "It's awesome! Like a miracle, a complete changeover. I no longer feel the tooth loss, and can smile and chew with ease, and be my normal self. Until now, I had read about modern medicine transforming people's lives, now I know how!"

London-based Sushma vividly remembers the time when as a squeamish 14-year-old, she used to watch her grandmother wear her false teeth (denture). "I thought, I don't ever want that to happen to me," says Ms. Gupta, now 58. Yet by the time she was in her mid-30s, she had lost several teeth. "Then, over the years, I developed gum disease, and my teeth began to loosen and shift, and I was just a mess," she said.

Four years ago, she had all her upper teeth and several lower teeth replaced with dental implants. "The dental implants look and feel natural," she says, "and I can eat anything I like." Sushma is delighted with the results.

About the surgery, she says, "The implant surgery was much less difficult than I thought it would be. At first, I was very afraid, but in fact, it was simpler than a root canal or a tooth extraction surgery."

"My dentures would fall out when I talked," says Mrs. Saroj Kohli, 72, a housewife from Delhi. "I couldn't taste my food — in fact, I could hardly chew. It was the most miserable time of my entire life." Mrs. Kohli, who lost her teeth in her early 50s, eventually replaced her dentures with something better: dental implants.

Like Aditya, Sushma and Mrs. Kohli, millions of people go through the agony of tooth loss and suffer from its consequences. The causes of this loss can be many: the commonest being poor oral hygiene; however, sports injuries, vehicular trauma, accidents, certain diseases and genetic defects contribute in fair numbers. The best step forward is prevention. Practising good oral hygiene, wearing a protective mouth guard when playing sports, and consulting your dentist immediately in the case of an injury can help prolong the life of your natural teeth. However, millions of people are unable to safeguard their teeth from a host of conditions and suffer tooth loss. The malady runs across ages, gender and social divide.

*Following the injury*

*Post dental implant*

### Consequences of tooth loss

Losing teeth can have a devastating impact, and can create a lasting social, psychological and emotional turbulence. A good smile is a key to an individual's self-esteem and confidence, which play a critical role in his overall health and happiness. Nothing can set your mood for the day like looking in the mirror and feeling great about how you look. The belief that you look good can dramatically affect your self-image and quality of life. Missing teeth can change all that for the worse – by affecting not only your self-esteem and confidence, but also the way you live.

Human teeth have three basic functions: they enhance the good looks, assist in proper speech, and, most essentially, are critical for the proper chewing of food.

In general, when people lose one or more of their front teeth, they feel awkward, anxious, and nervous or self-conscious while going out in public. For this reason, they rush to a dental surgeon and seek an immediate remedy.

Most people, however, tend to be casual about the loss of one or more molars, the teeth at the back of the mouth, which help chew food. This can have grim consequences. The jawbone suffers, and begins to deteriorate. The accelerated bone loss makes it softer and more vulnerable. Over time, the loss is compounded: the remaining teeth begin to shift in an attempt to fill the newly created space caused by the tooth loss. This shift produces a malocclusion: the upper and lower sets of teeth no longer match with each other. Normal chewing becomes difficult and the victim may suffer a sore jaw and unexplained headaches. As more teeth are lost, the remaining teeth must work harder. This extra burden accelerates their decay and demise.

With the loss of teeth, the appearance of the face also suffers. Bereft of the carry that teeth offer to the muscles of the face, facial muscles sag and droop, resulting in deep facial lines.

The presence of teeth is critical also for maintaining the distance between the upper and lower jaws. When teeth are lost, the jaws collapse towards each other. This results in undue prominence of the chin and thin lips. As a result, the individual begins to look much older.

The loss and shifting of teeth also leads to speech problems, which leads to much social embarrassment and produces much emotional pain and distress for the individual.

The reduced ability to chew also affects the choice of foods. Many people take to soft diet, which does not require them to chew. Such soft diets are often high in carbohydrate and low in protein. This can produce malnutrition in the long run.

## Options for tooth replacement

If tooth loss is unavoidable for you, there are many workable options for replacement that can help rescue your good health and smile. The options can broadly be categorised into two types: one, those that are removable, and the others, which remain fixed. The removable ones include a partial or full denture, while dental crowns, dental bridges and dental implants can be considered as the fixed replacements.

### Dentures

Dentures are a removable prosthesis that replaces the missing teeth in a jaw. They can either be partial or complete.

### Partial Dentures

A partial denture is a removable replacement for one or more missing teeth and adjoining tissues. They fill in the spaces created by missing teeth and prevent other teeth from shifting position.

### Complete Dentures

Individuals who have lost most or all of their teeth are a candidate for complete dentures. There are two kinds of complete dentures: "immediate," which are inserted immediately following removal of the natural teeth, and "conventional," which are placed in the mouth about eight to 12 weeks after tooth removal.

Not many people, however, find the dentures acceptable. They are cumbersome, and not easy to adjust to. Before going to sleep, a user must take them out. Many users also worry about a denture slipping at a wrong moment and causing social embarrassment. Dentures may also produce gum irritation and physical pain, and cannot be used for partaking of certain foods.

Dentures often only work well for those people, who are looking for an economical way of finding a tooth replacement.

### Fixed Bridge

A dental bridge is a false tooth, which is fused between two porcelain crowns to fill in the area left by a missing tooth. The two crowns holding it in place are attached onto the two adjoining teeth on each side of the false tooth. This is known as a fixed bridge. This procedure is used to replace one or more missing teeth.

The underlying substructure of a fixed bridge is made up of metal or ceramic material, but the restorations are typically identical to natural teeth. Dental bridges generally last for a period of seven to 15 years. A good oral hygiene is must.

A fixed bridge is more economical than a dental implant, and that is its biggest advantage. However, its biggest drawback is that its fitment requires altering perfectly healthy adjoining teeth; only then they can act as anchors for the bridge. In many people, dental bridges cannot also be fitted for the want of healthy teeth to secure them with.

### Danger of bone loss

Both dentures and fixed bridges suffer from a major drawback: they do not stop the bone loss in the jawbone that follows in the footsteps of the tooth loss.

The primary function of jawbone is to support the teeth. When a tooth is lost, the bone around the missing teeth begins to shrink. This process is called resorption. With passage of time, the bone shrinks to such an extent that it finds it difficult to hold a dental bridge or denture well. In that case, they fail to function well. Due to the bone loss, the face takes an older look.

## Emergence of dental implants

Dental technologists and research scientists have been hard at work, trying to find a most fitting alternative for natural tooth replacement. A device that would bind with the jawbone and gums, work in harmony with natural teeth, and fulfil the need of a lifetime of form and function.

The birth of dental implants is an outcome of this holy quest. The concept is simple and straightforward. Where the lost tooth once had its roots, the dental surgeon first fixes a titanium screw in the same portion of the jawbone. And once this titanium screw binds well with the bone, a single-tooth crown, larger bridge or denture is secured on the top of it, with the titanium screw acting as a post.

The biggest advantage of a dental implant is it does not wiggle or slip, as dentures can, and it helps preserve the gums and jawbone.

## 7KHELJXNVWRU

Strange to recount, but dental surgeons have been experimenting with the idea of tooth implants since the times of the Pharaohs. Down the ages, tooth implants were crafted out of wood, ivory and a host of metals. None could do the job well: they lasted no more than a few years and opened the tissue to possible infection.

The big breakthrough came in the year 1952. Indeed, it was no more than a fluky accident. A Swedish university professor, Dr. Per-Ingvar Branemark, was investigating into how a living bone tissue recovers from wounds. The tiny titanium microscope he had inserted into the living bone became stuck in the bone tissue. This led him to a long string of careful experiments. Lo and behold, in no time, he could see that titanium easily fused with the bone tissue and did not evoke any unfavourable reaction.

Buoyed by his observations of this new phenomenon, Branemark developed the tools and technique for implanting a titanium screw (post) to anchor “false teeth” by 1965. Over the years, the technique was perfected by conducting repeated clinical studies. By late 1980s, medical companies started manufacturing and marketing dental implants on a large scale.

Since the initial cost was high, in the beginning the use of dental implants was limited mainly to the Western countries. However, over time, as the manufacturing methods evolved and implant designs improved, the affordability became better. Today, dental implants have gained in popularity and usage the world over. Millions of people benefit from this modern marvel of medicine.

## Stages of implant treatment

The dental implant treatment has four phases: first a treatment plan is drawn, second a titanium implant is fixed into the jawbone, third a tooth crown is fitted on the top of the implant, and fourth, due care is taken to maintain a good oral hygiene.

### *Stage I: Drawing a treatment plan*

The dental surgeon will have the X-rays taken and create a model of the existing teeth. This will help determine how the implant should be placed. Occasionally, the individual may also require a bone or gum tissue graft. This may be needed to augment the site for placement of the implant.

### *Stage II: Fixing the implant*

The titanium implant is planted into the jawbone. It is allowed sufficient time to bind in, before a crown is set on it. This usually takes three to six months.

### *Stage III: Fitting the tooth crown*

The crown of the tooth is fitted on the top of the rock solid titanium screw, which has by now found a firm embedment in the jawbone.

In some people, however, the surgeon may not need to wait for that long. If the biomechanical conditions are good, the dental surgeon may fit a tooth crown the same day as the implant.

Yet again, in some cases, a dental implant can be fixed just after the tooth extraction. This has the benefit of limiting bone loss.

### *Stage IV: Safeguarding the oral hygiene*

Maintaining a good dental hygiene is the key to the long-term success of a dental implant. This must become a part of the daily regime in patient’s routine.

## 'LIFXOWLHVLWKGHQWDOLPSODQWWUHDWPHQW

Firstly, a dental implant is a rather expensive and lengthy procedure. Unlike a dental bridge, which can be fitted in a few days, fixing a dental implant usually takes about three to six months and it costs between Rs. 15,000 to Rs. 50,000 a piece.

Secondly, not everybody makes a good candidate for a dental implant. Some individuals may not have a sufficient bit of healthy bone in the jaw to support a titanium implant. Others may suffer from a poor general health. A person with diabetes or a smoker has a lower rate of success with a dental implant because of a poorer blood supply, which impedes a healthy fusion between bone tissue and the implant. The recipient must also have healthy gums. Before undergoing the treatment, a person may require periodontal treatment to get rid of the plaque and tartar on the teeth and gums.

## Age of constant innovation and progress

The field of dental implants has been going through a constant evolution. Today, due to better designs and bone grafting methods, hardly anybody needs to be refused a dental implant. Highly specialised procedures allow a dental surgeon to restore the jawbone and allow it to hold a dental implant. The design of crowns, bridges and dentures has also evolved and they are now so designed that they can attach more firmly to an implant.

The appearance of dental implants has also been undergone a major refinement. At first, they were crafted out of grey titanium metal, but now a white coloured polymeric implant is being employed. This special polymer, known commonly by the name “biopic”, fuses with the bone just as well and enjoys a natural tooth like brilliance.

With these developments, dental implants have truly come of age. They offer a new vista of hope and wellbeing today for those millions of people, who have suffered a tooth loss.

*(Based on an interview with Dr. S.P. Aggarwal, Medical Director, Green Park Dental Institute and Research Centre, New Delhi, and tête-à-tête with individuals who have undergone this treatment)*

# Recent developments in science and technology

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## Raman spectroscopy to check liquids in hand baggage

The present airline security rules do not allow passengers to carry liquids – a large bottle of shampoo, perfume, or even drinks


*A scanner using spatially offset Raman spectroscopy can reveal the contents of packaged items that may conceal explosives or drugs (Credit: Cobalt Light Systems)*

– in their hand baggage on flight because the scanners used for checking hand baggage do not reveal the contents of packaged items, especially liquids. But all that might change soon. Researchers in Europe have developed a scanner for use at airports that uses modified Raman spectroscopy to screen liquids in opaque or translucent bottles. The scanner is currently on trial at several European airports and might allow the ban on liquids of more than 100 ml in hand luggage to be lifted as early as next year. The new scanner uses a technology known as 'Spatially Offset Raman Spectroscopy', or SORS, which has turned out to be a powerful new technique for the non-invasive detection and identification of concealed substances, especially explosives and drugs.

Detection of explosives and their precursors through containers or packaging presents a big challenge to security personnel at airports. The problem is compounded by the wide variety of packaging in which the explosives can be concealed. Raman spectroscopy offers a viable solution due to its high chemical specificity and compatibility with mixtures and with water. But conventional Raman spectroscopy cannot be used because fluorescence and Raman interference due to the packaging material, being stronger than the signals from the contents, mask the latter. SORS overcomes this problem and allows a chemical analysis deep within a sample that can be used to scan everything from drugs in plastic packs to liquids in opaque bottles.

The basic SORS technique relies on the fact that most materials are neither completely transparent to light nor completely block it, but that they tend to scatter the light. An example is when a red laser pointer illuminates the tip of a finger – the light scatters throughout all of the tissue in the finger. Wherever the light goes there will be some inelastic scattering due to the Raman Effect. So, at some point, most parts of an object will generate a detectable Raman signal, even if it is not at the surface. The trick with SORS is to make a measurement that avoids the strongest signals emanating from the packaging materials. A simple analogy would be looking at the sky during the day. Although we know that there are stars in the sky throughout the day, we cannot see them because they are masked by the bright light of the Sun. But if a total eclipse blocks the light of the Sun, the stars become visible. So also with SORS; the surface signals are blocked out to see the pure signal from the sample body. The researchers use SORS to collect scattered photons from a spot a few millimetres away from the illuminated area – a "spatially offset" spot. That is why it is called spatially offset Raman spectroscopy.

SORS is versatile technique. Apart from detecting explosives and drugs, it is already being used in the pharmaceutical industry to test and identify raw materials as they come into a processing plant without needing to open the packaging, and to check in a non-invasive manner if the concentration of active chemical ingredients in a drug is accurate.

## New technique to understand Parkinsonism

Parkinson's disease or Parkinsonism is a progressive disease of the nervous system marked by tremor, muscular rigidity, and slow, imprecise movement that leads to shaking and difficulty with walking, writing, and speech. Parkinsonism most often develops after the age of 50 years and is one of the most common nervous system disorders of the elderly. In some cases, Parkinson's disease runs in families. When a young person is affected, it is usually because of a form of the disease that runs in families.

The root of Parkinsonism lies in the brain. In healthy persons, nerve cells use a brain chemical called dopamine to help control muscle movement. Parkinson's disease or Parkinsonism occurs when the nerve cells in the brain that make dopamine are slowly destroyed. Without dopamine, the nerve cells in that part of the brain cannot properly send messages, leading to the loss of muscle function that characterises Parkinsonism. The damage gets worse with time. Exactly why these brain cells waste away is unknown.

Parkinsonism is prevalent in all parts of the world. According to one study the incidence of the disease in India is about 70-90 per 100,000. In other words, some 7-9 million people suffer from Parkinsonism in India and the figure is likely to rise in view of the growing number of aged people in the country.

Till recently, research on Parkinsonism was limited to the study of the function and degeneration of neurons in the adult and aging brain, which did not help much in understanding the underlying cause of the disease. Recently, researchers of the Institute of Reconstructive Neurobiology, University of Bonn, Germany have developed a technique

## A unique journal

*Journal of Visualized Experiments* (*JoVE*) is a unique peer reviewed online research journal, which publishes research in a combination of video and text format. The experiments reported in a paper are presented in a video format, showing full details of the experimental procedures along with graphics and tables. This mode of publication conveys much more about an experiment than a printed paper can ever do. Visualisation greatly facilitates the understanding and efficient reproduction of both basic and complex experimental techniques, thereby addressing two of the biggest challenges faced by today's research community, especially in life sciences, viz., i. low transparency and poor reproducibility of biological experiments, and ii. time and labour-intensive nature of learning new experimental techniques. The videos accompanying each paper could be helpful to students in learning different experimental techniques used in research. The video journal is indexed by PubMed, the international database accessing primarily the MEDLINE database of references and abstracts on life sciences and biomedical topics.


*A page from Journal of Video Experiments showing the video of the experiment described in the paper (Credit: JoVE)*

for studying the development of the brain cells responsible for the disease using a new slicing method. The new technique allows scientists to observe for the first time how these cells behave during development. The study was published online in the *Journal of Visualized Experiments* (*JoVE*) on 31 January 2012. According to Sandra Blaess, lead author of the paper, the new technique also makes the cells available for genetic manipulation, and more information about how these cells develop and function could lead to new treatment options for Parkinsonism, raising new hope for the hapless patients.

### How the zebra got its stripes

The familiar term "zebra crossings" that mark pedestrian crossings on roads comes from the characteristic black-and-white stripes on the coat of the zebra. But why do the zebra have stripes? The striped appearance of zebras has provoked much speculation about its function and why the pattern has evolved, but experimental evidence has been scarce. Now a team of researchers from Hungary and Sweden led by Gábor Horváth of Eötvös University, Budapest have come up with a viable explanation. According to them, the stripes on zebra coat make the animal "unattractive" and keep blood-sucking horsefiles away (*Journal of Experimental Biology*, 1 March 2012 | doi: 10.1242/jeb.065540). Horseflies deliver nasty bites, carry disease and are a horse's most irritating enemy.

*Zebra's stripes are designed to keep away blood-sucking horseflies.*

According to the researchers, horseflies are attracted to horizontally polarised light because reflections from water are horizontally polarised and can be used to identify stretches of water where they can mate and lay eggs. Animal coats also polarise light, but only dark coloured coats do so. For instance, black and brown horses produce horizontally polarised light, which means that the light that bounces off the horse's dark coat travels in waves that move along a horizontal plane, like a snake slithering along with its body flat to the floor. These "flat" waves of light reflected from their coat makes the dark-coloured horses very attractive to horseflies. In contrast, light reflected from a white-coloured coat is not polarised and is much less attractive to the flies. As a result, white-coated horses are much less troubled by horseflies than their dark-coloured relatives.

Since the horseflies are attracted to dark coats but not to white coats, the researchers wanted to find out how they would react to a striped coat, and how this would affect their biting behaviour. To find out, they created an experimental set-up where they painted different black-and-white striped patterns onto boards and placed a black-painted board, a white-painted board, and several boards painted with stripes of varying widths in one of the fields of a horsefly-infested horse farm in rural Hungary. They also coated each board with insect glue to trap the flies and counted the number of horseflies that each one attracted.

They had expected that the striped pattern would attract an intermediate number of flies between the white and dark painted boards, but were surprised to find that the striped board attracted the least number of horseflies. When the researchers measured the stripe widths and polarisation patterns of light reflected from real zebra hides, they found that the zebra's pattern correlated well with the patterns that were least attractive to

*Horseflies deliver nasty bites, carry disease, and are a horse's most irritating enemy.*

horseflies. They concluded that zebras have evolved a coat pattern in which the stripes are narrow enough to ensure minimum attractiveness to horseflies. Interestingly, the researchers also pointed out that developing zebra embryos start out with a dark skin, but go on to develop white stripes before birth.

## The mystery of spider web stability solved

Scientists have long known of the incredible strength of spider silk, but this property alone could not explain how spider webs survive multiple tears and strong winds. A recent study by researcher from the Massachusetts Institute of Technology in Cambridge, USA and the Politecnico di Torino in Italy led by Markus Buehler of MIT that combined experimental observations of spider webs with complex computer simulations shows that the durability of a web depends not only on silk strength, but on the overall web design. The researchers modelled webs on computer and also investigated those spun *in situ* by *Nephila clavipes* – a species of golden orb spider, and found that the strands of silk adapt to the amount of stress they experience, and how that stress is loaded onto them.

Through computer modelling of the web, the researchers were able to efficiently create 'synthetic' webs, constructed out of virtual silks that resembled more typical engineering materials with varying properties. With the models, they could make comparisons between the modelled web's performance and the performance seen in the webs made from natural spider silk. In addition, they could analyse the web in terms of energy, and details of the local stress and strain. The stability of the web, they found, depends on how it compensates for damage and the response of individual strands to continuously varying stresses (*Nature*, 2 February 2012 | doi:10.1038/nature10739). The researchers found that the spider web is so designed that it localises strain and damage, preserving the web as a whole.

The spider webs are made from multiple silk types, but two types, known as viscid silk and dragline silk are most critical to the integrity of the web. Viscid silk is stretchy, wet and sticky, and it is the silk that winds out in increasing spirals from the web centre. Its primary function is to capture prey. Dragline silk is composed of a suite of proteins with a unique molecular structure

*Nephila clavipes, the golden orb spider, in its web (Credit: Robert Jensen)*

that lends both strength and flexibility. Dragline silk is stiff and dry, and it serves as the threads that radiate out from a web's centre, providing structural support. Dragline silk is crucial to the mechanical behaviour of the web. The study showed that when any part of a web is perturbed, the whole web reacts. Such sensitivity is what alerts a spider to the struggling of a trapped insect.

Under a light stress such as a gentle breeze, the silk softens and extends, thus allowing the web to retain its structure. But when stressed by a stronger force such as strong wind or a poking finger, the silk strands first extend and then the most stretched of those strands become suddenly rigid and break. This sacrifice of a strand or two limits the damage to a small area, keeping the rest of the web intact. Once the disturbance has passed, the spider can scurry out to repair the web, rather than being forced to rebuild.

The study showed that, when any part of a web is perturbed, the whole web reacts. Such sensitivity is what alerts a spider to the struggling of a trapped insect. However, the radial and spiral filaments each play different roles in damping the motion, and when stresses are particularly harsh, they are sacrificed so that the entire web may survive. According to the researchers, the sacrificial nature of spider silk could also lead to improved infrastructure designs in many other sectors including power grids and the Web.

## Letters to the editor

### The Mysterious Pi

The article "The Mysterious Pi" (Dream 2047, February 2012) was interesting and really informative. Thanks for youreffort in bringing such valuable information to common people like us. I wish you all the best.

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I read article 'The Mysterious Pi' by RintuNath in the February issue of Dream 2047. Congratulations for such an interestingand informative article. Its climax is the last section ' Why trilliondigits?' It presents interesting and very real justification for the wholeexercise of finding the value of pie to so many decimal places, which I did notknow.

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### Golden magazine

I am one of the readers of this golden magazine. First of all, I would thank to Vigyan Prasar and its team for giving us such an informative magazine. *Dream 2047* keeps me always informed about current news of science. I really like the editorials of Anuj sinha. He shares his experience with us. Biman Basu's articles give us information about new discoveries in science. I also got information about scientists who were unknown to me.

Shweta R. Kompa,
Bhudhawarpeth, Akkalkot, Maharashtra.

### Good medical articles

I have been a regular reader of your column in *Dream 2047*. The recent article "Winning ways with Asthma" was a very nice one giving all minute details. I am writing to you from a town where people don't get access to good medical treatment as there is a single civil hospital with minimal facility. Very soon a medical college will come here, but you will be surprised to learn that even educated people here try to get treatment for different disease here by so called magic spells! I hope you will continue to publish such articles and share your vast knowledge with common people.

Leeladhar Chouhan
Kokrajhar, Assam

### A good source of information

I read almost all the issues of *Dream 2047*. It is really very good magazine. Every article provides new information and updates. I really like to read the column of Biman Basu because I love astronomy very much. I am interested in learning everything about astronomy and this magazine helps me to learn a lot.

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