



DREAM 2047

March 2013

Vol. 15

No. 6

Rs. 5.00

Thirty Metre Telescope A new window to the Universe



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Some important insights regarding the objective and process of S&T communication: A synthesis



Dr. R. Gopichandran

The importance of public participation to fulfil the goals of sustainable development cannot be over-emphasised. This statement duly recognises the fact that the process of development that enables sustainability is as important as the goal. However, citizens have to comprehend the goals, approaches, tools and techniques and indicators of interventions in a logical manner to be able to enable such transitions effectively. These are important dimensions of “development communication” wherein the ability of citizens to receive and comprehend information is strengthened through targeted communication interventions. Science and technology communication plays a critical role in this context.

Institutions engaged in science and technology communication and the community of practitioners will do well to know about some of the most important sources of information that deal with the process of such communication and assessing their impacts. The objective of the present editorial is to highlight some interesting sources of such information.

The meta-review by Vladimir de Semir is a case in point. The publication presents a snapshot regarding the Declaration on Science and the Use of Scientific Knowledge (1999) at a World Conference on Science sponsored by UNESCO. The need to share scientific knowledge leading up to cooperation between governments, the civil society, business, and scientists was highlighted with a special emphasis on ethical standards.

That several challenges pertaining to environmental, public health, and bio-resources management have been the triggers for the call for collective and well-informed action have been indicated. This is in addition to a focus on the links between the preparedness of individuals, societies and cultures with preferences regarding aesthetics. The debate regarding the role of the “science communicator” and “scientist communicator” is also quite insightful. Importantly, the publication lists several challenges in science communication including myths about monolithic structure of the public with respect to perceptions, responses and voices of intermediaries. Such important aspects as duties of scientists to communicate and the right of the public to know and engage have also been highlighted. This aspect gains enormous significance, especially when access to information has become easier across political and language boundaries than in the past century.

Communicators engaged with the media in particular will derive valuable insights about the dynamics of communication from this very important publication. The chapter on public engagement in

science is particularly thought provoking since it highlights assumptions and related premises, especially regarding the links between science literacy and expected public support as a function of trust, perceptions or preparedness. Practitioners engaged in public consultations will also benefit from the insights stated. (Vladimir de Semir 2010, ‘Science Communication and Science Journalism’. Meta-Review. www.mediaforscience.com/Resources/documentos/booklet_en.pdf (accessed on 09 February 2013)).

Hilty and Ruddy (2010) discussed the dynamics of sustainable development in a natural science context using ICT (Information and Communication Technology) tools. They highlight such aspects as dematerialisation and role of ICT in addition to drawing attention to the Geneva Plan of Action with special reference to the e-Environment. The special emphasis is on environmental protection and sustainable use of natural resources with implications for safe disposal and recycling of hardware and components used in information and communication technologies. In this context communicators should take note of techno-optimistic and techno-pessimistic use of ICT. (Hilty Lorenz M and Ruddy, Tomas F 2010. Sustainable development and ICT interpreted in a natural science context, *Information, Communication & Society*. 13:1, 7-22 doi:10.1080/13691180903322805.

Science communicators have to comprehend the implications of the spread and depth of information that is presented by them, aligned with an understanding of the preparedness of end users of such information. This is a very important responsibility that has to be fulfilled with adequate care so that the receiver of information does not lose sight of all important dimensions of the pros and cons of the insights proposed through the communication. This is particularly so in the case of understanding the relevance of energy alternatives due to the nature of externalities the energy sources generate. This could also be true in the case of messages regarding interventions for management of landscapes through crops and associated vegetation. It will be useful therefore to design and implement awareness assessment programmes in the form of forerunners to large-scale campaigns. Such forerunners will help deliver appropriate information aligned with the preparedness of the receivers of information to comprehend and respond suitably.

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Published and Printed by Dr. Subodh Mahanti on behalf of Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi - 110 016 and Printed at Aravali Printers & Publishers Pvt. Ltd., W-30, Okhla Industrial Area, Phase-II, New Delhi-110 020
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Edavaleth Kakkat Janaki Ammal

A Path-breaking Botanist and Geneticist



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“Living for well over 80 years of which three scores were spent in scientific research, Janaki Ammal stands out as one of the most eminent and distinguished scientists of the country... Her list of publications is a remarkable one, not just for its length, but through the breadth of interests it reveals—sugarcane, horticultural plants, medicinal plants, trees, polyploids (natural and induced), chromosome behaviour, speciation, cytogeography, interspecific and intergenetic hybridization and finally phytogeography.”

S. Kedharnath in *Biographical Memoirs of Fellows of the Indian National Science Academy*, Vol. 13, 1988

“Viewing her life and her work, I would say this of Ammal: From a young age, she was endowed with the courage to make choices and the versatility to change course and adapt where and when required. With her passion for plants, she defined for herself her goals and purpose, and her mission in life. Having done that, she kept her mission above everything else and stuck to it till the end.

C. V. Subramanian in *Resonance*, June 2007

Edavaleth Ekkat Janaki Ammal (usually known as Janaki Ammal) was a botanist and plant cytologist of international fame. Her field of specialisation was cytology, the study of the structure and functions of the cell. She made pioneering contributions to genetics, evolution, phytobiology and ethnobotany. Her studies in ethnobotany, particularly in use of plants by the tribals of Kerala, were highly appreciated. She began studying the genetic makeup of plants at a time when this line of investigation had just come up. Janaki Ammal contributed significantly in enhancing our understanding of how plants cross-breed in the wild. She concluded that higher rate of plant speciation found in the cold and humid northeast Himalayas compared to the dry and cold northwest Himalayas might be attributed to polyploidy. She studied the effect of the Himalayan uplift on the genetic composition of the flora of Asia. She studied all kinds of plants—crop plants, garden plants, plantation crops, medicinal plants, wild plants and so on. The most important genera of plants studied by Janaki Ammal included *Saccharum*, *Solanum*, *Cymbopogon*, *Datura*, *Mentha*, *Viburnum*, *Rhododendron*, *Dioscorea*, *Dianthus*, *Nerine*, *Philadelphus*, *Rauwolfia*, *Terminalia*, *Emblica*, *Eucalyptus*, *Nicandra*, and *Kniphofia*. The plants and the chromosomes of which have been studied by Janaki Ammal are too numerous to mention. She, jointly with C. D. Darlington, wrote *The Chromosome Atlas of Cultivated Plants* (1945), a publication which became well-



Janaki Ammal

known among the botanists and agricultural scientists all over the world. This valuable compilation incorporated many of the species studied by Janaki Ammal. She was a founder member of the Indian Academy of Sciences, Bengaluru established by C.V. Raman in 1935. In fact, she was the first woman Fellow of the Academy.

Janaki Ammal's life is truly inspiring and is worth emulating not only because of her path-breaking scientific contributions but also because of her personal attributes. Her personal qualities have been highlighted by C.V. Subramanian: “Ammal was a thoroughly Indian in attire and habits, and Gandhian in her lifestyle. She was too selfless

to seek favours or the limelight and yet honours came to her unsought, something that is true of many great women and men... When required, she did not shirk fighting for a cause or for a right. Her integrity and professional ethics are far beyond doubt. She lived up to her own definition of greatness which combined virtue in life and passion in the pursuit of her science. There is thus much for us to emulate in her life and work.”

Janaki Ammal was born on 4 November 1897 in Tellichery, Kerala (then part of Madras Presidency). Her parents were Srimathi Devaki and Shri E. K. Krishnan. She had six brothers and five sisters. Her father was in the judicial service of the Madras Presidency. Janaki Ammal's initial schooling was at the Sacred Heart Convent in her hometown and then moved to Chennai (then Madras). At Chennai she first studied at Queen Mary's College, a prestigious educational institution for women and then at the Presidency College. In 1921, she obtained her BA (Honours) degree of Madras University. She joined the Women's Christian College as Lecturer in Botany. In 1923, she qualified for an MA degree of Madras University. In 1924, she went to the University of Michigan, USA as a Barbour Scholar and from there she obtained her MSc degree in 1925. It may be noted that in 1914 a scholarship programme was established by funds provided by Levi L. Barbour (1840-1925) for women of the highest academic and professional career from the Orient to study modern science,



Women's Christian College, Chennai

medicine, mathematics and other academic disciplines and professions critical to the development of their native lands.

In 1926 Janaki Ammal came back to India and again started teaching botany at Women's Christian College, this time as Professor of Botany. She again went to Michigan University as the first Oriental Barbour Research Fellow and obtained her DSc degree in 1931. After coming back to India from USA armed with a DSc degree she again opted for a teaching assignment at the Maharaja's College of Science at Thiruvananthapuram (then Trivandrum).

Apparently she was not content with teaching and so she switched over to research. Commenting on her choice of career Subramanian wrote: "Her life reflects her experiments in settling for a career and, more importantly, for a mission. First, she took to teaching. Not content, she took to research. Her two innings in Michigan were crucial in determining the choice of her specialisation in plant sciences: she chose cytology which in those formative years of the science was concerned primarily with the nucleus and the chromosomes."

Janaki Ammal's first whole-time research assignment was at the Sugarcane Breeding Station (later renamed as Sugarcane Breeding Institute), Coimbatore. Even long before Janaki Ammal joined the institute it had acquired international fame. C.A. Barber

and T.S. Venkataraman had initiated research in sugarcane breeding at the Station, which led to development of internationally famous cross-bred sugarcane varieties such as Co 419 with drought- and disease-resistant qualities. The Coimbatore varieties of sugarcane were not only cultivated throughout India but also in other countries where sugarcane was an important crop. Janaki Ammal



Jawaharlal Nehru



Sugarcane Breeding Institute, Coimbatore



T.S. Venkataraman

joined the Breeding Station as a geneticist. At Coimbatore, where she worked during the period 1934-39, she did pioneering cytological work on sugarcane (*Saccharum officinarum*) and allied species. In fact she led the foundation for cytogenetical studies on *Saccharum* and allied genera. She made several interspecific and intergeneric hybrids involving sugarcane and related grass species and genera such as *Bambusa* (bamboo).

In 1939, Janaki Ammal left India for England, where she spent the next 10 years (1939-1950). In England first she worked as Assistant Cytologist at the John Innes Horticultural Institution, London (1939-45) and then as Cytologist at the Royal Horticultural Society, Weasley, London. While working in England, she studied chromosomes of a wide variety of garden plants and in many cases her findings led to the understanding of the evolution of species and varieties.

In 1951, Janaki Ammal came back to India at the invitation of India's first Prime

Minister Pandit Jawaharlal Nehru, who was looking for qualified Indians working abroad to take care of the existing institutions and build new institutions in independent India. She served the Government of India in various capacities. Janaki Ammal's first assignment was to revamp the Botanical Survey of India (BSI), which had been depleted of its qualified personnel due to

the exodus of the British.

In a period of two years working as the Officer-on-Special-Duty she reorganised the Botanical Survey of India. She then became the Director of the Central Botanical Laboratory, a post she held for five years (1954-59). The Laboratory was first temporarily located at Chatter Manzil, Lucknow

and then shifted to Allahabad. In 1959, she moved to Regional Research Laboratory (RRL) of the Council of Scientific and Industrial Research at Jammu as Officer-on-Special-Duty for a period of three years (1964-69). Later she officiated as the Chairman of the Cytogenetics Division of RRL, Jammu for two years (1962-64). She spent another five years (1964-69) at Jammu (now named as Indian Institute of Integrative Medicine) working as Emeritus Scientist at the RRL and also as Honorary Professor of Botany at the University of Jammu. It was at Jammu that Janaki Ammal developed her interest in mountain flora. Based on her comparative studies of the different regions

of the Himalayas she demonstrated how Chinese, Burmese and Malaysian strains of plants got mixed there.

In November 1970, after spending a short period of about a year at the Bhabha Atomic Research Centre (BARC), Mumbai as Visiting Professor she finally decided to settle in Chennai. She continued to do research work till the end of life (precisely, till she was hospitalised two weeks before her death). She was associated with the Centre for Advanced Study in Botany of the Madras University and lived and worked at the Field Station of the Centre of Advanced Study in Botany at Maduravoyal, about 15 km from Chennai. After her retirement she concentrated her attention on medicinal plants and ethnobotany. She developed a garden of medicinal plants at the Field Station.

Janaki Ammal was conferred an honorary LL.D by the University of Michigan in 1956 in recognition of her pioneering contribution to botany and cytogenetics. The citation noted that 'blessed with the ability to make painstaking and accurate observations, she and her patient endeavours stand out as a model for serious and dedicated scientific

workers.' She was a Fellow of a number of academic bodies including the Indian National Academy of Science, the Linnaean Society, the Royal Geographic Society, the Genetics Society of England, the Genetics Society of America, the British Association for the Advancement of Science, the Indian Society of Genetics and Plant Breeding, and the Botanical Society of India. She was elected President of the Botanical Society of India (1960) and also of the Indian Society of Genetics and Plant Breeding (1961). In 1957, she was honoured with Padma Shri by the Government of India. The herbarium at the Regional Research Laboratory, Jammu has been named after her. The herbarium houses over 25,000 species taken from different parts of India including species collected even prior to 1935. The oldest specimen preserved in the herbarium is *Nephradium malle* collected by E.N. Trotter from Chamba in 1888. The Ministry of Environment and Forests, Government of India, instituted the E. K. Janaki Ammal Taxonomy Award in 1999.

She died on 7 February 1984 at the age of 86 years. Her first research paper was published in 1931 and the last in 1985 (after

her death). Janaki Ammal's active research career spanned over five decades. She lived a true life in science.

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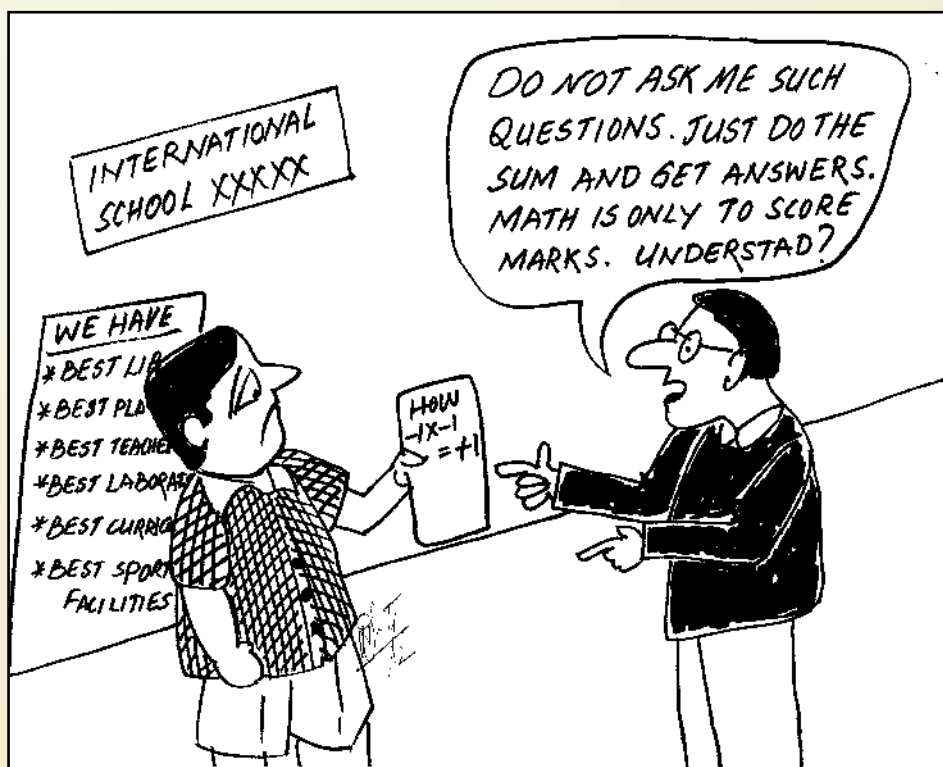
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(The article is a popular presentation of the important points on the life and work of Edavaleth Kakkat Janaki Ammal available in the existing literature. The idea is to inspire the younger generation to know more about Janaki Ammal. The sources consulted for writing this article have been listed. However, the sources on the Internet have not been individually listed. The author is grateful to all those authors whose writings have contributed to writing this article. The author is also grateful to the sources from which the illustrations/photographs have been reproduced.)

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Cartoon by : V.S.S. Sastri E-mail: vsassastri@gmail.com

A Glance on the Golden Ratio

Last week, I went to watch a Charlie Chaplin movie titled 'The Gold Rush' in a retrospective film festival. It is a characteristic Chaplin comedy interwoven with a mixture of different human emotions. I was talking about the film with my uncle that evening. He told me that the theme of the film was indeed based on a true incidence. The Klondike Gold Rush (also called the Yukon or Alaska Gold Rush), was a migration of an estimated 100,000 prospectors between 1896 and 1899 to the Klondike region of the Yukon in north-western Canada where a large deposit of gold was discovered. It was an extremely difficult journey in a very rough terrain and cold climate, and only 30,000 could reach at the destination while only 4000 were succeeded to find gold.

'Gold always remained a precious metal for all civilisations, and the history down the years was written around the gold,' I commented.

'Yes, the touch of gold can be found everywhere - from the history to the modern day finance.'

'An example, uncle...'

'Well, here is a clue for you. Can you find the connection between these words: age, mean, rule, share, goal, ratio?'

'I guess that the connection is something associated with gold.'

'You guessed it correctly. The connection is the adjective form of the noun 'gold'.'

'The adjective form of gold is golden.'

'You got it right. You can use the adjective *golden* for all these words'

'Let me give it a try. The first one is: 'golden age'. I know that it's often quoted in the historical incidence. For example: the golden age or the golden era of the Moghul dynasty...'

'Good Googol. In History, 'golden age' refers to the period when an activity, art, skill etc. was at its peak or the period that encompasses peace, prosperity and happiness of people.'

'The next ones are 'golden mean' and 'golden rule'. I'm not much sure about these!'

'Philosophically, the terms 'golden mean' and 'golden rule' have special meanings. In philosophy, especially that of Aristotle,

the 'golden mean' is the desirable middle path between two extremes, one of excess and the other of deficiency. For example, the 'courage', a virtue, if taken to excess would manifest as recklessness, and if deficient as cowardice. The 'golden rule' or 'golden ethic' has also philosophical connection. It means the ethical code or morality that essentially states one should treat others as one would like others to treat oneself.'

'The word 'golden share' must be associated with the financial world.'

'You are right. Mostly in Britain, a share in a company that gives control of at least 51% of the voting rights, especially when held by Government is termed as a 'golden share'. You may also know that the precious metal is very important for the economy of any country and it is characterised by 'gold reserve' which is the quantity of gold held by a central bank of a country.'

'I know about the next one. The 'golden goal' is the first goal scored during the extra time of a football match. The golden goal ends the match and gives victory to the scoring side.'

'Fantastic.'

'And the last one is 'golden ratio'. I presume that this must have some connection with mathematics.'

'You guessed it right Googol. The golden ratio is one of the most simple, elegant and beautiful ratios of the mathematical world.'

'I don't know anything about the golden ratio. Please uncle, tell me more about the golden ratio.'

'Well, before that let me see how you could make the golden connection here in this number series. Could you please tell me the connection between these numbers: 1, 1.618, 50 and 79?'

'Hmm, let me try again uncle. I can see the connection in two of these. If a person secures the *first* position in a race or competition, he or she is awarded the *gold* medal. The *fiftieth* anniversary of a significant event is called *golden* jubilee or anniversary.'

'Very good, Googol. And what is the chemical symbol of gold?'

'The chemical symbol of gold is *Au*. Yes I got it now. The *atomic number* of *gold* is 79.'

'And finally, the number 1.618

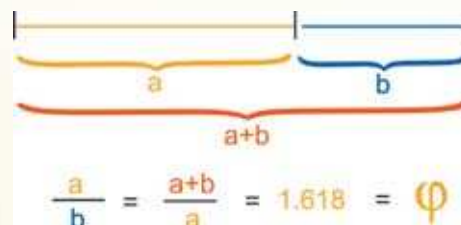


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represents the *golden ratio*.'

'That's very interesting. What's special about this number?'



'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.'

'You just told me that 1.618 is the part of the golden ratio. What is the exact value of the golden ratio?'

'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. The golden ratio is denoted by a symbol Φ (Greek upper case letter called 'phi'). A variant of golden ratio is called the golden rectangle'

'What is the golden rectangle?'

'A 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.'

"It is interesting to see mathematics blends in arts," I commented.

"You are right, Googol. Mathematicians have studied the golden ratio because of its unique and interesting properties."

"Uncle, you have explained how to calculate golden ratio using line segments. However, golden ratio is irrational number, that is, it cannot be expressed as the ratio of two numbers," I wanted to know.

"Good question. That is the reason 1.618 is only approximate value of the golden ratio. You can also calculate this using algebra. Step 1: take any integer, say, n . Step 2: Take reciprocal of n , i.e. $1/n$. Step 3: add 1 to it. New number is $(1/n + 1)$. Now treat this number as n and repeat steps 1 to 3 many times. More number of iteration you do, more closure you reach in calculating the golden ratio. However, you can never claim to reach the final result."

"It's very interesting. How mathematicians knew about the golden ratio?"

How to calculate the golden ratio

Step 1 Number (n)	Step 2 $1/n$	Step 3 $1 + 1/n$
2	$1/2 = 0.5$	$0.5 + 1 = 1.5$
1.5	$1/1.5 = 0.666...$	$0.666... + 1 = 1.666...$
1.666...	$1/1.666... = 0.6$	$0.6 + 1 = 1.6$
1.6	$1/1.6 = 0.625$	$0.625 + 1 = 1.625$
1.625	$1/1.625 = 0.6154...$	$0.6154... + 1 = 1.6154...$
1.6154...		

"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*."

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 approximately 1.618. Through the ages other names have been attached to this wonderful ratio including *golden mean*, *golden number*, and *divine proportion*."

"Please tell me what happened after that."

"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. Italian mathematician Bartolomeo de Pacioli (also known as Luca Pacioli) 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."

"It is interesting that Leonardo da Vinci's name is also associated with the golden ratio. Did he use the golden ratio in his paintings?"

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

proportions exhibit the golden ratio."

"It is interesting to know that the golden ratio is important not only in mathematical world, but also in arts."

"Indeed it is. 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."

"Please tell me some applications of the golden ratio."

"The golden ratio is also associated with Fibonacci series, 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. There is a special relationship between the golden ratio and the Fibonacci series."

"Yes uncle, I have also heard about Fibonacci series. Please tell me how the golden ratio is related to this series," I wanted to know.

"Ratio of any two successive numbers in Fibonacci series is close to the golden ratio. Like *golden ratio*, there are amazing connections between *Fibonacci numbers* and natural forms. For example, number of spirals in a pine cone, sunflower seed arrangement and many more natural phenomena obey Fibonacci series. 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."

"Is there any latest discovery related to the golden ratio?" I wanted to know.

"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."

"Uncle, I think that Charlie Chaplin is the golden ratio of the film world."

"And why do you think so, Googol?"

"The golden number is an example of the beauty and elegance of the complex mathematical world while Charlie Chaplin represents the slapstick and comedy face of the mundane, monotonous and serious human life."

"That's indeed a reasonable comparison, Googol."

[A part of this article appeared in the March 2011 issue of Dream 2047 written by the same author.]

Thirty Metre Telescope:

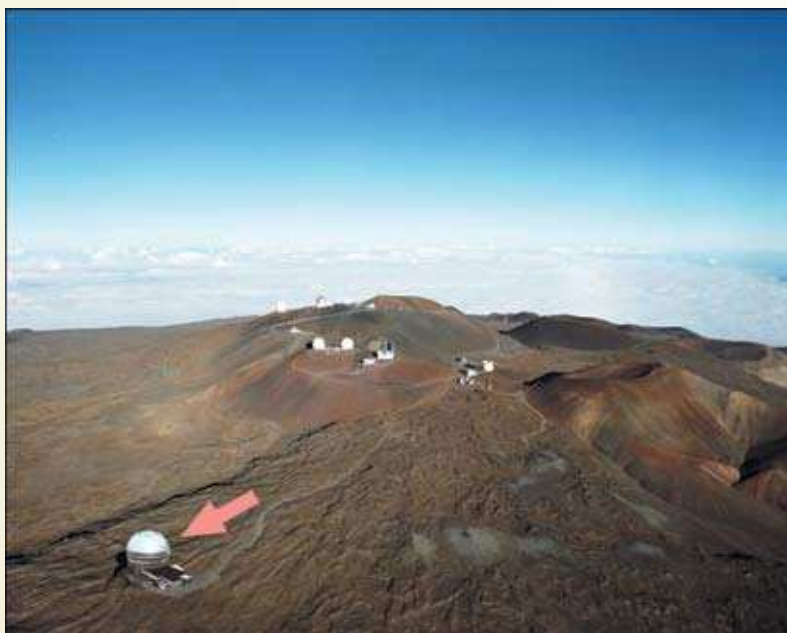
A new window to the Universe

After the Large Hadron Collider at CERN, Indian scientists are again going to contribute significantly to yet another international mega science project – the Thirty Metre Telescope (TMT). Dubbed as the world's most advanced ground-based observatory operating in optical and mid-infrared wavelengths, the giant telescope will be built just below the summit of Mauna Kea volcano in Hawaii. The total cost of the TMT project is estimated at about \$1.4 billion out of which India's contribution will be about \$140 million (about Rs.770 crore). Seventy-five per cent of India's contribution will be in the shape of key components and software for the telescope and the rest in cash. India's contribution to TMT will be jointly funded by the Department of Science and Technology and Department of Atomic Energy, Government of India. The other partner nations contributing to TMT are China, Japan, Canada and the US. The TMT project is led by the California Institute of Technology (CalTech), University of California, and Association of Canadian Universities for Research in Astronomy (ACURA).

The TMT Governing Board met in New Delhi in January 2013 to review the status of the project and the contributions to be made by partner nations India, China, Japan, Canada and the US. Briefing media after the meeting, the TMT Project Manager Gary Sanders announced that construction work on the telescope will begin next year and the first light is expected in 2021. Henry Yang, Chairman of the TMT Governing Board, was happy that India will be an integral part of the next generation of astronomical research as a part of TMT because "India is well recognised and respected as one of the top-ranking countries in the field of basic research". Edward Stone, Vice-chairman of the Governing Board, said the TMT and

its partners are extremely pleased that India has selected TMT as their next-generation astronomical research project.

The three main institutes spearheading Indian activities for TMT are the Aryabhata Research Institute for Observational Sciences



Location of TMT on Mauna Kea (arrow)

(ARIES), Nainital; the Indian Institute of Astrophysics (IIA), Bangalore; and the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune. The activities will be coordinated by the India TMT Coordination Centre (ITCC) of which IIA is the nodal agency.

A giant telescope

Ever since the Italian astronomer Galileo Galilei turned his small telescope skywards and revolutionised astronomy, telescopes have come a long way. Today's telescopes can see much farther than Galileo could ever have imagined. Yet, today's cutting-edge telescopes are reaching their limits as they probe further into space in an effort to find the faintest stars and



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observe the most distant galaxies. The Thirty Metre Telescope was conceived to continue this journey of exploration and engineers, astronomers, and project specialists are working to build this next-generation observatory for the astronomical community. With TMT, it will be possible to study the universe as never before, finding answers to many of the grand challenges of science.

The Thirty Metre Telescope is basically a reflecting telescope, like several others found in observatories around the world that use a large mirror to gather light from distant stars. But the TMT will use a primary mirror much larger than any existing telescope. As the name suggests, it will use a mirror with an effective

diameter of 30 metres that will have nine times the light-collecting area of the largest optical telescopes in use today. But it will not be a single-piece mirror; it will be made up of 492 hexagonal mirror segments, each 1.44 m in size, 74 of which will be



Artist's rendering of TMT showing the 30-metre diameter primary mirror.

fabricated in India. Precisely aligned, these segments will work as a single reflecting surface of 30 m diameter, with a total reflecting area of more than 650 square metres.

Keeping the giant primary mirror in correct hyperboloid shape would need precise positioning of all 492 hexagonal mirror segments with respect to each other and would involve development of new technologies in mechanics, electronics, optics, and control software. These segments need to be maintained at the required surface accuracy and stability, against structural deformations caused by temperature, gravity, wind and seismic vibrations. The precise positioning of the mirror segment will be done using edge sensors and actuators. The edge sensors would be used to measure relative displacement, tip and tilt of the mirror segments. A total of 3,234 edge sensors – 12 for each segment – will be used in the TMT. The actuators will be used to make minor adjustments of the position of the individual mirror segments to keep them precisely aligned within a few nanometres. India will provide 74 segments of the main mirror and the complete segment support assemblies consisting of the edge sensors and actuators for the TMT. A major part of the observatory control software will also be developed and provided by India.

According to B. Eswar Reddy of Indian Institute of Astrophysics, Bangalore, who is the Programme Director, India TMT Coordination Centre, several Indian companies are gearing up to play a major role in the construction of the TMT and a few firms have been selected following a very stringent process. A commercial firm in Puducherry has already been assigned the work to produce prototype edge sensors for testing. The job of producing prototype actuators has been assigned to a firm in Bangalore.

Countering atmospheric turbulence

Despite its large size, the TMT will be a ground based telescope and will be prone to instabilities of the atmosphere that cause the stars to twinkle. When light from a star or another astronomical object enters the Earth's atmosphere, atmospheric turbulence can distort and move the image in various



Sketch of the 30-m diameter primary mirror made of 492 hexagonal segments.

ways. As a result, images produced by any telescope larger than a few metres are blurred by these distortions. But modern ground-based telescopes are well-equipped to counter distortions caused by atmospheric turbulence using a technique called 'adaptive optics'. In adaptive optics, a computer-controlled deformable mirror is used to correct wave front errors in an astronomical telescope, allowing astronomers to achieve an unprecedented sharpness of faint astronomical sources at optical wavelengths.

An adaptive optics system uses a point source of light, usually a bright star in the sky as a reference beacon to measure the effects of the atmosphere. In the absence of a bright star in the vicinity of the object of interest, an alternative reference light source, called a 'laser guide star', is used as reference beacon. At the telescope, light from the reference star is analysed by a detector called a 'wave front sensor' that measures the distortion and sends signals to a high-speed computer to deform a secondary mirror to correct the

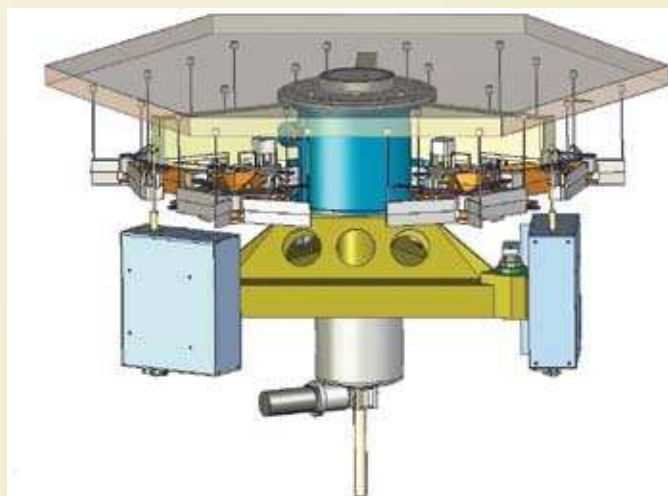
distortion. The improvement in image quality achieved by using adaptive optics is said to be as dramatic as "someone who has had 20/150 vision all his life getting fitted with glasses and seeing the world with 20/20 eyes for the first time." China is to provide the 'Laser Guide Star Facility' for adaptive optics system of the TMT.

What will TMT achieve?

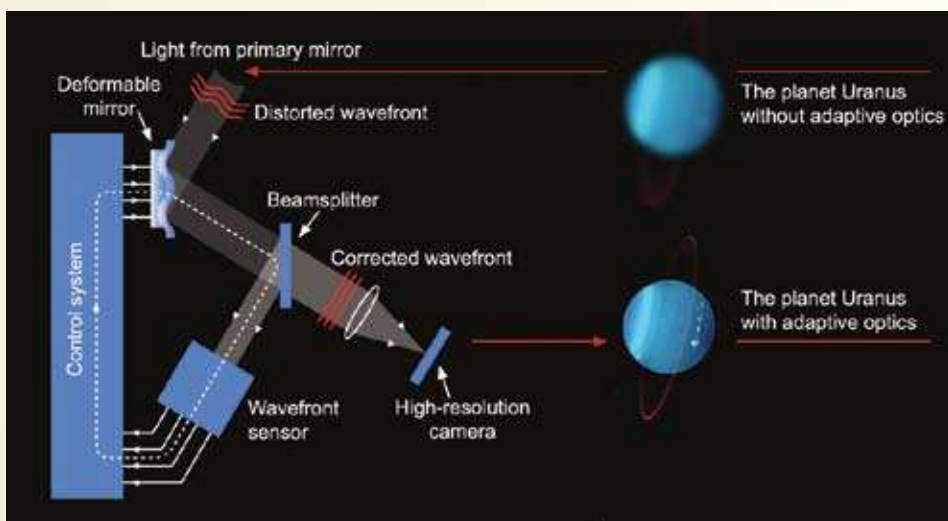
Despite being ground based, the TMT will be much more powerful than the orbiting Hubble Space Telescope or the upcoming James Webb Space Telescope because of the enormous light gathering power of its giant primary mirror. This makes the TMT much more effective for spectroscopy and study of faint objects compared to any space-based telescope which essentially carries a much smaller primary mirror.

When completed in 2021, the TMT will allow astronomers to directly explore the early Universe, from the end of the cosmic dark ages through the formation of the first stars and re-ionisation and into the epoch of galaxy formation. TMT also will make important contributions to the study of dark energy by pushing supernovae observations to the highest possible redshifts and measuring the dark energy density as a function of cosmic time.

The TMT will also transform our knowledge of the Solar System. With its integrated adaptive optics system, TMT will achieve an astounding resolution of approximately 8 milliarcseconds (one milliarcsecond is one thousandth of an



Mechanical design of the segment support assembly that will support each mirror segment.

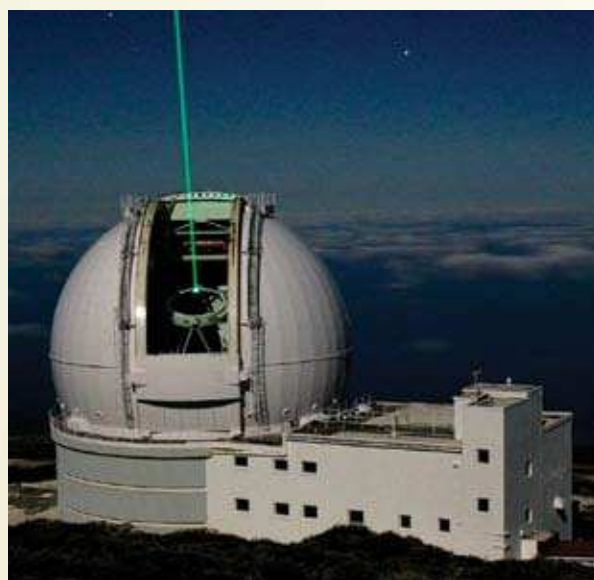


In adaptive optics, the deformable mirror, wave front sensor, and control system perform real-time corrections to the atmospheric distortions.

arcsecond, which is $1/3,600$ of a measure of angle in degree) at a wavelength of 1 micrometre, which corresponds to 25 kilometres at the distance of Jupiter. TMT also will be able to obtain spatially resolved spectra to study the atmospheric and surface chemistry of the outer planets and their moons, and monitor these objects for weather, volcanism, and tectonic activity.

Through its unprecedented light-collecting area, TMT will enable new horizons in the study of the Kuiper Belt, which contain a vast swarm of small icy bodies that preserve details of the formation of the Solar System and the materials out of which the planets formed. The composition of these bodies is best determined through observations in the near-infrared wavelengths. TMT and its infrared capabilities are expected to provide spectroscopic analysis of potentially thousands of moderately faint Kuiper Belt Objects. The spatial resolution and sensitivity of TMT will allow individual stars to be resolved even in very crowded fields.

With its enormous light gathering power and exceptionally high resolution, the TMT is likely to vastly hasten the discovery of exoplanets. Approximately 300 planetary systems have been identified till date. The vast majority of these have been detected through measurement of the periodic motion of the host star due to the gravitational perturbation of orbiting planets. TMT is



By projecting a laser into the sky astronomers can create an artificial guide star for use in adaptive optics.

expected to expand the number of host stars accessible to Doppler spectroscopy by a factor of 30. TMT's hundred-fold increase in sensitivity over current generation telescopes will reduce the necessary observing time for these studies from 1-3 hours to as little as 1.5 minutes.

TMT also will expand the new frontier of directly imaging entire planetary systems. With its large aperture and advanced adaptive optics, TMT will be able to produce images and spectra of Uranus- and Saturn-like planets orbiting nearby stars, image proto-planets forming around young stars, and perhaps even detect the nearest "super-Earth" planets. Current simulations also suggest that TMT would be able to detect the spectral signatures of water, carbon dioxide, and ozone in transiting Earth-like planets. Though not direct biomarkers, these

molecules are indicative of planets that could support life.

India's involvement in the TMT project is recognition of its capability in astronomical research and offers a unique opportunity to carry out frontline research in astronomy. It will also help develop cutting-edge science and technology that is required to build and operate the next-generation observatories. It will also provide Indian astronomers and students a share of the observation time at TMT. Moreover, as part of the project, several key technologies related to astronomy are being transferred to India, which will help our scientists and engineers to master these technologies that may eventually help in building indigenous 8-10-m class telescope facilities on Indian soil.

Articles
invited

Dream 2047

Vigyan Prasar invites original popular science articles for publication in its monthly science magazine *Dream 2047*. At present the magazine has 50,000 subscribers. The article may be limited to 3,000 words and can be written in English or Hindi. Regular columns on i) Health ii) Recent developments in science and technology are also welcome. Honorarium, as per Vigyan Prasar norm, is paid to the author(s) if the article is accepted for publication. For details please log-on to www.vigyanprasar.gov.in



Statistics: The Art and Science of Numbers



Madhulika Dube

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Have you ever thought about what sets the select few winners in Las Vegas casinos apart from numerous losers? If you believe that winning at a card table is merely based on the cosmic positioning of stars such that Lady Luck seems to be favoring the winner, then perhaps you have not been properly introduced to my friend "Statistics". Allow me to do a formal introduction; meet Statistics, the art and science that plays with numbers. Statistics is a scientific discipline of ubiquitous influence that solves practical problems arising not only in applied sciences but in every field of study and even finds application in the day-to-day situations. It will not be wrong to say that statistics exists, not for itself, but to offer other disciplines a coherent set of ideas and tools for dealing with the data. Such a valuable and selfless tool, don't you think? In all honesty, mankind has been employing statistical tricks for thousands of years without realising it. Do you know the current ODI batting average of Sachin 'God' Tendulkar? You do? Then surely you do know that some statistical mumbo-jumbo is involved in the calculation of that figure. As the great statistician and economist of our age Sir Arthur Bowley once said "*Knowledge of statistics is like the knowledge of foreign languages or of algebra; it may prove of use at any time under any circumstances.*"

Statistics in olden days was known as the "Science of Kings" as the kings required facts and figures of their states for better administration. In India, Kautilya's *Arthashastra* contained detailed instructions for the conduct of agricultural, population and economic census for the purpose of taxation. Aristotle's *Polity* contained comparative description of states. The Holy Bible starts with instructions to Moses to conduct a census of fighting men of Israel. Statistics in those days was in vogue merely for official purpose, fundamentally the quantitative study of demography and economics. It's no wonder then, European mathematicians and economists during sixteenth and seventeenth

century, namely Graunt and William Petty who collected and worked with census data, called this discipline *Political Arithmetic*. However, later the word statistics was derived from the Latin word *Statisticum Collegium* meaning a lecture on the affairs of the state. The word statistics is actually credited to the German scholar Gottfried Achenwall who coined it in 1749. Today, the scope of statistics is much wider and touches almost every sphere of life, with continuously developing new areas of applications. Interestingly it's been a symbiotic interaction, since the challenging problems in various disciplines have contributed towards tremendous strides in development of statistics.

Initial work in the scientific discipline of statistics was directed towards development of the probability theory. The tremendous success of physics and astronomy in Europe during the 17th and 18th century gave rise to the belief that the secrets of nature could completely be unfolded. Probability being the science of uncertainty gradually gained momentum to quantify the "laws of nature". Apart from this, the contribution to the development of probability came from an unexpected field - gambling. During mid-17th century some French and English mathematicians who were also fond of gambling, worked on challenging problems of games of chance. Prominent among them were Pascal, Fermat, and de Moivre. Later Thomas Bayes, Laplace and Gauss also contributed significantly to the development of probability.



Blaise Pascal

Blaise Pascal (1623-1662) is perhaps one of the most brilliant figures in the history of mathematics and statistics. Pascal not only contributed towards the development of probability but also invented *Pascaline*, the first mechanical calculator. A child prodigy, he was only a teenager when he started his pioneering work on calculating machines in an effort to ease his father's endless exhausting



Abraham de Moivre

calculations of taxes owed and paid, and eventually came up with the first calculating machine. His famous letters to Fermat, another renowned mathematician of those times, laid the foundations of probability. Indeed, Statistics owes a lot to Pascal.

Another genius whose contribution paved the way towards development in statistics was Abraham de Moivre (1667-1754). Although mathematics was not a part of his course work as a student, de Moivre read several mathematical works on his own. He received formal training in mathematics for the first time at the age of 17. Despite the late

start, de Moivre's incredible achievements changed the tide of development of statistics. His most important contribution in statistics is the statement of the formula for normal distribution. He deduced that the normal curve is the limit to which the binomial curve approaches. He also generalised Newton's famous binomial theorem into the multinomial theorem, published "The Doctrine of Chance" in 1718 which is considered to be the Bible of probability and applied the theory of probability to gambling problems and actuarial tables. Throughout his life de Moivre remained poor and to make some money he used to visit Slaughter's coffee house in London where gamblers would pay him to calculate odds for them. de Moivre continued studying the fields of probability and mathematics until his death in 1754 and several additional papers were published after his death.



Jacob Bernoulli

Jacob Bernoulli (1655-1705) was another stalwart of probability. Initially trained in theology, the study of Christian faith and God's relation to the world but made his own escape into mathematics. He was the first to use the term "Integral" which we so frequently use in mathematics. Jacob's most

important work was *Ars Conjectandi*, which was published after his death in 1713 and is considered to be the first major treatise in the field of probability and statistics.

Statistics as a subject began to develop with the publications of De Moivre and Jacob Bernoulli. These treatises are the towers of statistics based on which the entire world of statistics developed. De Moivre and Bernoulli were both refugees. Statistics as a science came of age on the fringes of that harsh but indubitable point of origin.

It may seem surprising, but highly significant contributions in statistics came from people who studied theology. Like Bernoulli, Thomas Bayes (1702-1761) also studied theology and logic in his beginning years. Believed to be the first to treat probability inductively, Thomas Bayes was privately educated and established a mathematical basis for probability.

His contributions are immortalised by the modern Bayesian statistics. Today, Bayesian methods are used everywhere; from medical diagnostics through biotechnological methods to banking and finance, NASA's Mission Control Center and Intel, and the list is endless. Interestingly, Bayes never published what would eventually become his most famous accomplishment; his notes were edited and published after his death.

Carl Friederich Gauss (1777-1855) is considered to the greatest mathematician/statistician of modern times. He is placed with Archimedes and Newton for his profound understanding of numbers. Gauss was a child prodigy and displayed exceptional talent for mental computation. When he was only nine, the class teacher, to keep the class busy, asked the students to add one hundred numbers. While other students struggled for hours, Gauss immediately wrote down the answer. He simply observed that $(1+100) = 101$, $(2+99) = 101$, $(3+98) = 101$, ... $(50+51) = 101$; i.e., 101, 50 times, so the total equals 5050. He put forward the principle of least squares and his calculation of the law of errors reestablished the utility of normal distribution in a new avatar which was already discovered by de Moivre. This distribution is justifiably called Gaussian in the honor of Gauss.



Thomas Bayes



Carl Friederich Gauss

Another person from theology was Pierre Simon Laplace (1749-1827). However, two enthusiastic teachers at the University of Cain evoked his interest in mathematics. He was sent to Paris with a letter addressed to d'Alembert, a renowned mathematician of that time. d'Alembert was not interested in taking Laplace, so gave him a thick book on mathematics asking him to come back only when he could completely read it. Laplace came back after a few days. Surprised and not believing that Laplace could have completely read the book, d'Alembert asked him some questions from the book. When Laplace could answer comfortably, d'Alembert was greatly impressed

and recommended him for a teaching place in E' Cole Militare, an institution for military higher education. Laplace's early published work in 1771 started with differential equations and finite differences, simultaneously working on the mathematical and philosophical concepts of probability and statistics. His phenomenal work in astronomy and statistics earned

him the title "French Newton" or Newton of France.

Florence Nightingale, the lady with the lamp, was not only a celebrated English nurse but also a writer and a statistician. Florence Nightingale's efforts made record keeping of patients and their statistical analysis to be a part of hospital routine. She famously said "the true foundation of theology is to ascertain the character of God. It is by the art of statistics that the laws in social sphere can be ascertained and codified. The study of statistics is thus a religious service".

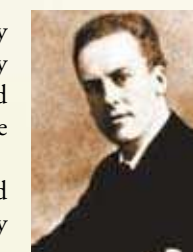
Statistics owes a lot to people from various other disciplines. One such person was Sir Francis Galton. Sir Francis Galton was a man of colossal achievements. He was a geographer, meteorologist, explorer, geneticist, psychologist,



Pierre Simon Laplace



Gregor Mendel



Karl Pearson



William S Gosset

and above all a great statistician. Cousin of renowned biologist Charles Darwin, Galton was very bright from the beginning. His contributions in statistics laid the foundations of regression analysis, which is perhaps one of the most popularly used statistical method in most of the researches carried out today. Gregor Mendel (1822-84) was an Austrian priest whose

name attracts high respects not only in statistics but in biological sciences as well. Mendel had studied philosophy and physics, but his attraction to research was only due to his love of nature. He cultivated

and tested some 29,000 pea plants in the large area around the monastery's garden which he used as his experimental field. Widely known as the "Father of genetics", his experiments on pea plants led him to conclude that the laws of heredity are statistical in nature. He published his work in 1866, but unfortunately that remained largely unnoticed. Long after his death, famous scholar Karl Pearson and still later Sir R.A. Fisher recognised his work through statistical studies of phenotypic variations.

Karl Pearson (1857-1936) is the man who has been credited for establishing the discipline of mathematical statistics. Like Galton, Karl Pearson was a multidisciplinary man. When the 23-year-old Albert Einstein started a study group, the Olympia Academy, he suggested that the first book to be read in the academy should be Pearson's *The Grammar of Science*. This book covered several themes that were later to become part of the theories of Einstein and other scientists. Pearson's work was all-embracing in the wide application and development of mathematical statistics, and encompassed the fields of biology, epidemiology, anthropometry, medicine and social history. In 1901, he founded the highly reputed journal *Biometrika*, whose object was the development of statistical theory.

William S Gosset (1876-1937) earned a degree in chemistry and worked in Guinness brewery. His work led him to investigate

the statistical validity of results obtained from small samples (previous statistical theory had concentrated only on large samples). Gosset's most important result is known as the "Student's t " distribution and test. His work founded the concept of quality control and discovered the utility of the Poisson distribution in biological applications. His publications in Pearson's journal *Biometrika* were signed "Student," because of the company's wish to keep secret the fact that they were gaining an industrial advantage from employing statisticians.

Sir Ronald Aymer Fisher (1890-1962) was truly a genius and laid the foundations of modern statistical methods. He not only worked in statistics but contributed extensively in evolutionary biology, eugenics and genetics. Fisher had very poor eyesight since childhood and due to this he was tutored in mathematics without pen and paper. Perhaps due to this training, he used to visualise the problems in geometrical terms and was able to solve the problems without writing any details. Fisher did outstanding work and gave novel ideas in statistics, genetics and evolutionary biology. His mammoth contribution in statistics earned him the title 'Father of modern statistics'.



Sir Ronald
Aymer Fisher

Ragnar Frisch (1895-1973) was a Norwegian economist and the co-winner of the first Nobel Prize in Economics in 1969. Frisch received his prize for his pioneering work in "Econometrics", the word which he coined, for using statistical techniques to test economic hypotheses. In econometrics he worked on time series and linear regression analysis. He also introduced econometric modeling to government economic planning and accounting. Tjalling C. Koopmans and Robert Engle were the other Noble Laureates in economics who were awarded for their contributions to the development of econometrics in 1975 and 2003 respectively.



Ragnar Frisch

Statistics in India

In India, statistics as a scientific discipline was introduced by Prasanta Chandra Mahalanobis. Although he was a physicist, he was highly influenced by the works of Karl Pearson and R. A. Fisher as a student

at Cambridge. As a Professor of Physics at Presidency College, Calcutta (now Kolkata) he carried out a number of statistical studies during his tenure and widely propagated the application of statistics. In 1931, with some of his colleagues from diverse fields who were actively engaged in his statistical laboratory, he established the Indian Statistical Institute in Kolkata. The Indian Statistical Institute started short training courses in statistics which were attended by officers on deputation from the government and other organisations from all over India. It was Mahalanobis who initiated the statistical movement in the country and through his efforts the

statistical methods were employed in planning for the economic development of the country after independence. Mahalanobis also started the Indian journal of statistics, *Sankhya* in 1931, which is considered to be one of the finest journals of statistics. For his contributions, he was appointed Honorary Statistical Advisor in 1949 and was instrumental in creation of the Central Statistical Organisation (CSO) and the National Sample Survey Organisation (NSSO) to collect the socio-economic data through sample surveys.

The history of statistics in India is chiefly the history of Prof. P.C. Mahalanobis whose influence on changing aspects of his country's changing life is probably unique among all statisticians. The ISI, CSO, NSSO, *Sankhya* and the approach used by the Central Planning Commission are tributes to his imagination and effective leadership. Without Prof. Mahalanobis, the status of statistics in India and the shape of second and third Five Year Plans would have been very different.

Indian Statistical Institute since its establishment has produced several world renowned statisticians. No wonder Indians have dominated the statistical scene on the world map. One such man is Professor C. R. Rao, whose basic work in statistics is taught at UG and PG level all over the world. He held several important positions in India and abroad and at the age of 91 is Professor Emeritus at Penn State University and Research Professor at University of Buffalo in USA. The American Statistical Society has described him as "a living legend whose work

has influenced not only statistics but has had far reaching influences in varied fields such as economics, genetics, anthropology, geology, national planning, demography, biometry and medicine". Rao has been decorated with Padma Vibhushan by Indian Government besides being honoured with numerous honorary degrees by several countries for his work in statistics.

Another milestone in the popularisation of statistics in India came with the establishment of Indian Agricultural Statistics Research Institute (IASRI). Devastating famines in Bengal and the absence of any authentic information available with the concerned administration on crop production in different provinces of the country necessitated the establishment of a dedicated data collection and analysis centre to promote Green Revolution in India. The Indian Council of Agricultural Research was entrusted with the task of evolving suitable methodology for estimation of annual production of crops. Prof. P.V. Sukhatme, a statistician at ICAR along with other co-workers evolved efficient techniques through crop cutting experiments to estimate the crop production in the country. Today, IASRI is counted amongst the premier institutes in Asian continent and has contributed immensely in the field of agriculture statistics with notable contributions towards the innovative ideas of sampling and statistical designs.

Due to paucity of space only those scholars are included here who changed the course of the tide of statistics. Development of a subject is a continuous process; even a small contribution initially may make significant changes later. The science of statistics is also dynamic. It is continuously moving forward and probing into new areas of applications. Today, education in statistics is more like that of a technologist; broad based and aimed at providing skills which can be used in decision making in almost all fields of human endeavor. It is indeed that generic technological field which provides entry to a rich prospect where almost no discipline is out of bounds. In words of Professor H.G. Wells "One day statistical thinking will be as necessary, for efficient citizenship, as reading and writing".

Professor Madhulika Dube, Department of Statistics, M. D. University, Rohtak

Gall stones

All You Want to Know About



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The gall bladder is a small, pear-shaped muscular sac, 7.5 to 15 cm long and 2.5 to 5 cm across at its widest point. It lies under the liver, and is located under its right lobe. Its key function is to store bile, a digestive fluid produced by the liver. The gall bladder releases the bile juice into the small intestine for the easy digestion of fat in the food.

Bile is composed, in part, of water, electrolytes, cholesterol and bilirubin. Bilirubin is a greenish yellow waste product excreted by the liver that gives bile its colour. If it gets into the blood, it can cause the skin and eyes to turn yellow, a condition that's known as jaundice. Bile also contains bile salts and the chemical lecithin that together dissolve cholesterol and allow it to be excreted by the liver.

When a person eats a meal containing fat, the gallbladder contracts and empties bile through a small tube called bile duct, which leads to the upper portion of the small intestine, the duodenum. The bile helps the small intestine digest and absorb fat and certain vitamins. When bile becomes chemically imbalanced, it can form into hardened particles, which can grow into stones. They can be as small as a grain of sand or bigger than a golf ball. While 20 per cent of people have just a single gallstone, most people have multiple stones which may number in tens or hundreds. Some also harbour "gravel" or "sand."

Most gallstones are a mixture of cholesterol and pigments. In about 1 in 5 cases, stones consist singly of cholesterol, and in about 1 in 20 cases, stones consist of pigments alone.



Gallstones are common

The estimates of frequency of gallstones in the population vary between geographic regions, and families. In most parts, about 1 in 10 people over the age of 40 are affected. In India, the northern region of the Gangetic plains is the most severely affected.

No age is exempt, and even children can have gallstones. Women are twice as likely to be affected by gallstones as men.

How do gallstones form?

Multiple factors contribute to the formation of gallstones, many of which aren't well understood. Factors that are recognized include:

Too much cholesterol

Normally, bile contains enough bile salts and lecithin to dissolve cholesterol that's excreted. But cholesterol isn't easily soluble. If bile has more cholesterol than can be dissolved, the excessive cholesterol can form into crystals and fuse into one or more stones of varying shapes and sizes. Obesity and a genetic predisposition may contribute to this process.

Incomplete or infrequent gallbladder emptying

The gallbladder may fail to contract and empty as it should. This may occur during pregnancy or prolonged fasting. The longer bile stays in the gallbladder, more water is absorbed in larger quantities and more concentrated the bile becomes. Bile that is too concentrated can become "sludgy" and form stones.

Types of gallstones

All gallstones do not have the same composition. They may be one of the following three varieties:

Cholesterol stones

They are made from cholesterol that bile is unable to keep dissolved. They are particularly more common in North India. Some are almost pure cholesterol, but more often the stones also contain considerable amounts of other components, such as bilirubin and calcium. These are sometimes called mixed stones.

Pigment stones

This type of stone forms when the bile contains very high levels of bilirubin. Pigment stones are intensely dark brown or black and generally small. One causes of their formation is not always apparent. Some are associated with excess production of bilirubin stemming from severe scarring of the liver (cirrhosis), or excessive red blood cell destruction and removal (haemolytic anaemia).

Primary bile duct stones

Cholesterol and pigment stones that escape and lodge in the bile ducts are known as secondary or retained duct stones. Primary bile duct stones are different in that they actually form within the bile ducts. These stones are usually soft and brown and are made of decomposed bile.

Recognising the symptoms

Gallstones usually settle at the bottom of a gallbladder, and most of the time they don't cause any problems. Some people associate gallstones with symptoms such as heartburn, indigestion or bloating. However, there is no evidence that gallbladder disease causes these symptoms.

Gallstone colic

In about 20 per cent people with gallstones, the stones lead to gallbladder colic. This intense and sudden pain, which may last for hours, happens when a stone in the gallbladder is lodged in the neck of the gallbladder or the cystic duct and obstructs gallbladder's opening. This buildup pressure in the gallbladder.

The attack may last 15 minutes to several hours. The pain usually begins shortly after eating. It begins in the upper right part of the abdomen just below the ribs and may shift to the back or right shoulder blade. Neither antacids nor pain relievers can relieve this continuous pain. You try changing your position: standing up, bending over, lying down. Nothing helps.

The pain may be accompanied by fever and nausea. After the pain subsides, the person may notice a mild aching sensation or soreness in the upper right abdomen.

Complications

Larger stones may get stuck at the entrance to the cystic duct, within a bile duct or at the entrance to the small intestine.

Gallbladder inflammation

Usually, a stone lodged at the entrance to the cystic duct will drop back down to the bottom of the gallbladder after a gallbladder attack has passed. If the stone doesn't work its way free, and simply migrates up to the neck (outlet) of the gallbladder, serious problems can occur. The gallbladder may suffer from inflammation and infection. The process is known as acute cholecystitis.

Obstructive jaundice

If a stone is lodged in the common bile duct, blocking flow of bile from the liver, the person may get jaundice. The skin and the whites of the eyes may turn yellow. Other symptoms may include fever, chills, dark-coloured urine, jaundice, and pale-coloured stools, depending on where a stone is lodged.

Acute Pancreatitis

Gallstones that collect at the entrance to the small intestine can block the pancreatic duct, causing inflammation of the pancreas. This condition is known as acute pancreatitis.

Free passage of gallstones

When the gallbladder contracts to expel bile into the small intestine, the stones may escape, or try to. Tiny stones usually can pass through the bile ducts, enter the small intestine and leave the body without causing any problems.

Who's at risk?

Gall stones can occur at all ages and in both sexes. However, why gallstones develop in some people and not in others is still unclear. These factors appear to put a person at increased risk:

Predisposed as a female

Gallstones are twice as common in women as in men. That may be because the hormone estrogen causes the liver to excrete more cholesterol into bile.

Pregnancy, birth control pills and hormone replacement therapy also increase the level of cholesterol in bile, and decrease the gallbladder's ability to completely empty bile. However, women should not stop taking birth control pills or hormone replacement therapy simply because of the risk of gallstones.

Excess weight

Several studies show that the more a person weighs, the greater is the risk. Obese people have a three-fold

to seven-fold greater risk of developing gallstones than people whose weight is normal.

Diet and dieting

A diet high in fat and sugar, combined with a sedentary lifestyle, increases the risk of gallstones. Fasting and rapid weight-loss diets also increase the risk of gallstone formation by altering levels of bile salts and cholesterol and throwing bile chemistry out of balance.

Some doctors prescribe a bile salt medication (ursodiol) for people in weight-loss programmes to offset potential build-up of stone-forming cholesterol. It helps dissolve cholesterol by improving the chemical balance in bile.

Age

Risk of gallstones increases with age. One reason might be that as people get older their body tends to secrete more cholesterol into bile.

Family history

Gallstones often run in families, pointing to a possible genetic link. Two genes that cause gallstones have been identified in mice and are being investigated in humans.

Ethnic group

People in the Gangetic plains of north India have the highest incidence of gallstones in India.

Preventive strategies

Recent research indicates that several preventive measures can be taken to inhibit the formation of gallstones:

Dietary measures

Take a diet high in fibre, low in fat, and rich in vitamin C. This is the most healthy diet, and besides inhibiting the formation of gallstones, will protect you from several ills, including possibly a number of cancers.

Regular eating habits help

Eat smaller meals at regular intervals. This helps keep the blood chemistry healthy, and keeps the blood sugar and cholesterol in the pink.

Control weight

Keep your weight in check. People who are overweight tend to accumulate excess cholesterol in their bile. Excess weight also decreases bile salt formation, as well as the ability of the gallbladder to contract and empty.

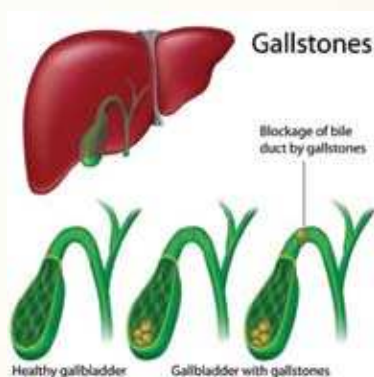
Avoid crash diets

Avoid rapid weight-loss diets. They are a recipe for acquiring gallstones.

Keep out of sun

Avoid overexposure to the sun. Besides running the risk of developing sunburn and skin cancer, you may also make yourself extra vulnerable to gallstones.

(Next month: Gallstones: diagnosis and treatment options)



Recent developments in science and technology

Egg consumption not linked to heart disease

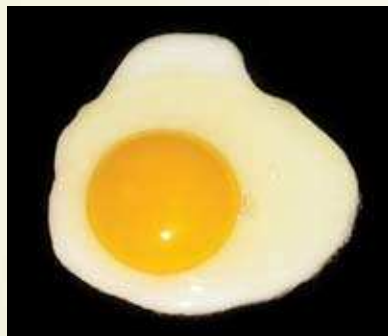
Cardiovascular disease is a public health problem that affects millions of people in developed and developing countries. In recent decades, several risk factors have been associated with cardiovascular disease, levels of low-density lipoprotein (LDL) cholesterol among them. In some studies, participants with the highest levels of LDL cholesterol showed a notably higher risk of cardiovascular events than those with the lowest levels. In addition, it was also reported that a reduction in concentrations of LDL cholesterol could significantly reduce the risk of coronary heart disease and incidence of stroke and mortality.

Diet is an important source of serum cholesterol, but dietary cholesterol has only a modest contribution to plasma concentrations of LDL cholesterol. To minimise the elevation of blood cholesterol and reduce the risk of cardiovascular disease, consumption of less than 300 mg/day of cholesterol has been recommended.

Since eggs are a major source of dietary cholesterol, with one large egg containing almost 210 mg of cholesterol, limiting consumption of eggs has been recommended. But eggs are also an inexpensive and low-calorie source of many other nutrients, including minerals, proteins, and unsaturated fatty acids, which could lower the risk of cardiovascular disease. Additionally, those on a carbohydrate restricted diet, dietary cholesterol from eggs could increase plasma concentrations of high-density lipoprotein (HDL) cholesterol, which is believed to protect against vascular disease. Therefore, it has been suggested that reducing egg intake might not be important for healthy people with normal levels of cholesterol in the blood. A significant number of experts now believe that egg consumption poses no risk to cardiovascular health, and some countries including Nepal,

Thailand, and South Africa even recommend consumption eggs every day or regularly as part of a healthy diet.

In a recent study, a group of researchers from China and Boston, USA, performed a meta-analysis of eight studies that included 263,938 participants for coronary heart disease and 210,404 participants for stroke and followed them for 8 to 22 years (a meta-analysis combines the results of several studies that address a set of related research hypotheses). The authors found no evidence for an



Eggs do not cause heart disease

association between egg consumption and either coronary heart disease or stroke. However, an increased risk for coronary heart disease was observed in patients with diabetes in the group of participants with the highest egg consumption compared with those with the lowest consumption. The findings were published in the *British Medical Journal* (7 January 2013, doi:10.1136/bmj.e8539). The authors concluded that the findings of their study “do not support a positive association between egg consumption and cardiovascular disease outcomes in the general population.” On the contrary, a protective effect against haemorrhagic stroke was observed in those with the highest egg consumption. According to the authors, even if eggs are ultimately found to be somewhat harmful – though that seems unlikely at this point – they are almost certainly better than the replacement foods – mostly containing starches, fats and sugars – toward which most people are likely to turn.

Breakthrough in DNA storage of digital data

Ever since the double-helix structure of DNA, chemically known as deoxyribonucleic acid, was deciphered by James Watson and Francis Crick in 1953, scientists have manipulated DNA in innumerable ways for a variety of purposes – to improve crop varieties, and

produce better drugs and vaccines, to name a few. The most recent achievement is of storing enormous amounts digital data in synthetic DNA strands that can revolutionise data storage and retrieval. The contents stored in DNA are “read” by sequencing the DNA – as is routinely done today, in genetic fingerprinting and so on – and turning it back into computer code.

In the latest research, Nick Goldman and colleagues at the European Bioinformatics Institute near Cambridge in UK succeeded in storing digital information by encoding it in the four different bases that make up DNA. Goldman and colleagues claim to have achieved a density of 2 petabytes (10^{15} bytes) per gram of DNA which, they calculate, would allow at least 100 million hours of high-definition video to be stored in a teacup (*Nature*, 23 January 2013 | doi:10.1038/nature11875). This is a thousand times larger than that achieved by Sriram Kosuri of Harvard Medical School and colleagues last year (*Science*, 28 September 2012).

The researchers collected data, which included an MP3 recording of Martin Luther King’s “I have a dream” speech; a digital photo of their lab; a pdf file of the landmark paper of 1953 that described the structure of DNA; a file of all of Shakespeare’s sonnets; and a document that describes the data storage technique, in the form of zeros and 1s in computer binary code, and transcribed them into “Base-3” code, which uses zeros, 1s and 2s. The data was transcribed for a second time into DNA code, which is based on the bases adenine (A), cytosine (C), guanine (G) and thymine (T). The letters (bases) were then turned into DNA molecules, using lab-dish chemicals.



Nick Goldman admires a vial of DNA data (Credit: European Molecular Biology Laboratory)

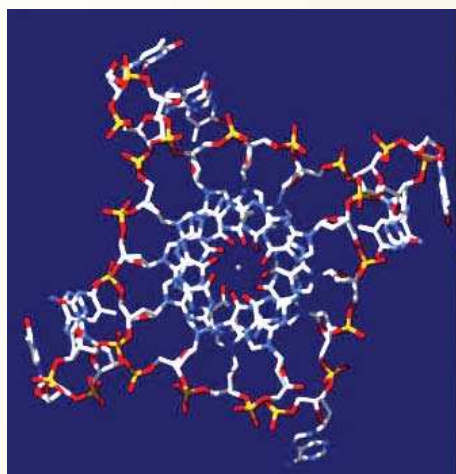
Since only short strings of DNA can be made, it means the data has to be chopped up into small sections of 117 letters, each attached to a tiny address tag, rather like packet-switching in Internet data, which enables data to be reassembled. In the study, the data could be recovered and the files could be read with 100-percent accuracy. The work did not entail using any living DNA, nor does it seek to create any life form. In fact the man-made code would be quite useless in anything biological, the researchers said.

The main advantage of the technique is that a speck of man-made DNA can hold mountains of data that can be freeze-dried, shipped and stored, potentially for thousands of years. However, according to the researchers, the main disadvantage of the technique is the time needed for data retrieval. Sequencing and reading the DNA takes a couple of weeks with present technology, so it is not suitable for jobs needing instant data retrieval. But it would be ideal for long-term storage of data.

‘Quadruple-helix’ DNA discovered

Sixty years after the historic revelation of the double-helix structure of DNA by Watson and Crick in 1953 comes the news of another remarkable discovery – that of four-stranded ‘quadruple-helix’ DNA structure in the human genome – by a team of researchers led by Shankar Balasubramanian at the University of Cambridge, UK (*Nature Chemistry*, 20 January 2013 | doi:10.1038/nchem.1548). The so-called ‘G-quadruplex structures’ of DNA have been known to scientists and they can easily be created in the laboratory by the folding of synthetic DNA double-helix strands rich in guanine, but their presence within living cells was not known earlier. Physical studies over the last couple of decades had shown that quadruplex DNA can form in the test tube, but the structure was considered to be a curiosity rather than a feature found in nature. Researchers have now shown for the first time that these structures actually form in the DNA of human cells.

The findings mark the culmination of over 10 years of investigation by scientists to show these complex structures in living human cells – working through computational modelling to synthetic lab experiments and finally the identification in human cancer



Four DNA strands come together in this model, built using data from x-ray crystallography. (Credit: Jean-Paul Rodriguez)

cells using fluorescent biomarkers. The study shows clear links between concentrations of four-stranded quadruplexes and the process of DNA replication, which is crucial for cell division and production.

A G-quadruplex comprises four guanines from different sites along a G-rich strand held together by a special type of hydrogen bonding to form a compact square structure that interrupts the DNA helix. The study indicates that quadruplexes are more likely to occur in genes of cells that are rapidly dividing. Cancers are usually driven by genes called oncogenes that have mutated to increase DNA replication – causing cell proliferation to spiral out of control, and leading to tumour growth. So, by targeting quadruplexes with synthetic molecules that trap and contain these DNA structures and thus prevent cells from replicating their DNA and consequently blocking cell division, scientists believe it may be possible to halt the runaway cell proliferation that is at the root of cancer growth. This research highlights the potential for exploiting these unusual DNA structures to beat cancer – the next step would be to figure out how to target them in tumour cells.

Dung beetles use Milky Way as guide

Dung beetles are beetles that feed partly or exclusively on faeces or dung. There are many kinds of dung beetles. Some, known as rollers, are noted for rolling dung into round balls, which are used as a food source or brooding chambers. Other dung beetles, known as tunnellers, bury the dung wherever

they find it. A third group, the dwellers neither roll nor burrow: they simply live in manure.

Remarkable as these insects are, living almost entirely on animal waste, they have another unique ability not found in the animal world. The dung beetle is now the first animal proven to use the light of the Milky Way to find direction at night, as found by a team of researchers from Wits University in Johannesburg, South Africa (*Current Biology*, 24 January 2013 | doi: 10.1016/j.cub.2012.12.034). Many species of birds are known to make use of star light as a navigation tool (in addition to magnetic field, smell, and vision), as well as certain species of insects. The cited paper provides the first documentation of animals using the Milky Way for navigation.

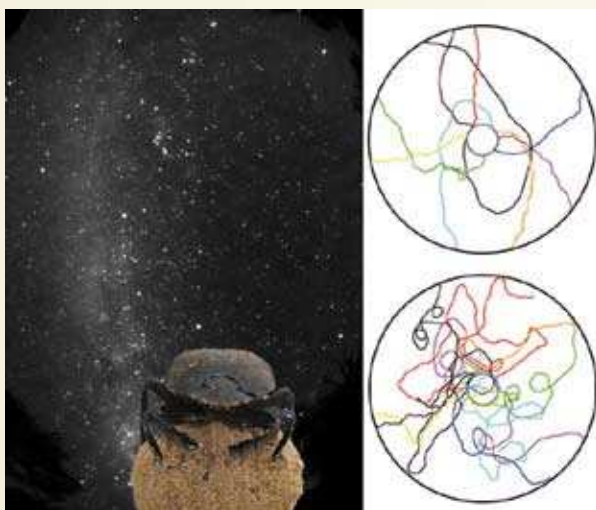
Dung beetles like to roll their dung balls in straight lines. When they find a pile of droppings, they shape a small ball and start pushing it away to a safe distance where they can eat it, usually underground. Since it moves backwards while pushing the dung ball, getting a good bearing is important because unless the insect rolls a direct course, it risks turning back towards the dung pile where another beetle will almost certainly try to steal its prized ball.

Vision scientist Marie Dacke of Lund University in Sweden, who led the study, had noticed in previous studies that even on moonless nights, dung beetles were able to move their dung balls in straight paths. For their study, the researchers put the beetles and their balls of dung in the centre of an



Dung beetle rolling a ball of dung backwards

arena of sand surrounded by a metre-high wall so nothing on the ground could be used as a point of reference. An overhead camera filmed their paths. The beetles’ performance was revealing. On clear nights when the Moon and stars were visible, the



Using starlight, dung beetles travel relatively straight (lines inside top circle). But when the night sky is hidden, the beetles had much more difficulty keeping a straight path to the periphery (bottom circle). [Credit: (left) Emily Baird; (right) Adapted From M. Dacke et al., *Current Biology*, 23 (2013)]

insects' trajectories were more or less straight. Even on a moonless night, the beetles were pretty efficient in their dung-rolling as long as the Milky Way was visible. But when the sky was overcast and the Milky Way was not visible, the insects went every which way but straight.

To prove their point the researchers did a second round of tests in which they placed the beetles and their dung balls in the centre of a wooden platform two metres across and clocked how long it took for them to reach the edge. With the Milky Way in sight, their paths led them to the edge of the platform in as little as 40 seconds. But with clouds blocking their view, it took them nearly two minutes. According to the researchers, this clearly shows that the beetles do not orientate to a single bright source of light such as the Moon or bright stars, but rather to the band of light that represents the Milky Way.

New technique to generate hydrogen on demand

Fuel cells are a clean source of electricity, but they need hydrogen to run, and producing and safely storing hydrogen is a major hurdle coming in the way of more widespread use of fuel cells. But a solution is in sight. Researchers have developed a technique of producing hydrogen by using nothing more than fine particles of silicon and water. A team of researchers led by Mark T. Swihart at the University of Buffalo in USA

have created spherical silicon nanoparticles they claim could lead to hydrogen generation on demand becoming a "just add water" affair. When the particles react with water, they rapidly form hydrogen and silicic acid, a nontoxic by-product, in a reaction that requires no light, heat or electricity. In experiments, the hydrogen produced was shown to be relatively pure by successfully being used to power a small fan via a small fuel cell (*Nano Letters*, 14 January 2013, doi: 10.1021/nl304680w).

According to the researchers, the rate of hydrogen production depended on the size of the silicon particles. 10-nanometre diameter particles

produced hydrogen 1,000 times faster than similar reactions using bulk silicon, and up to 150 times faster than silicon particles 100 nanometres in size. The 10-nanometre particles yielded more hydrogen in under a minute than the 100-nanometre particles yielded in around 45 minutes. This gives the smaller particles the potential to generate hydrogen on-demand for use in fuel cells to power portable devices. According to Swihart, the higher speed of the reaction with smaller particles is due to the spherical shape of the 10-nanometre particles. This is because larger particles form non-spherical structures that react less uniformly and readily with the water than the surfaces of the smaller, spherical particles.

The main disadvantage of the technique, according to the researchers, is the significant amount of energy and resources required to produce the smaller silicon particles, which would make the particles expensive and likely rule them out for widespread use in powering consumer electronic devices, initially. However, the technology could find applications in situations where water is available and portability is more important than cost, such as camping and military operations. The most practical application would be for portable energy sources. Instead of carrying diesel generators and fuel tanks, it could be enough to carry fuel cells and cartridges of silicon nanopowder and generate power by simply adding water. ■

Letters to editor

Ashima Chatterjee

Thank you ever so much for the article "Asima Chatterjee – First Woman General President of the Indian Science Congress" by Dr. Subodh Mahanti. I received a copy of *Dream 2047*, January 2013 issue from Professor Syamal Chakrabarti. It is the best "New Year" gift I have ever received. From your article I have got two valuable references on my mother and I hope to procure the books.

Please convey my profound regard and respect to Mr. Biman Basu. My mother had great affection for him. I remember that when there was any delay in receiving the proofs of our papers accepted in the *Indian Journal of Chemistry* she used to write to Mr. Basu.

Dr. (Mrs.) Julie Banerji
92, Acharya Prafulla Chandra Road,
Kolkata – 700009

Excellent article

I enjoyed going through the article "Pondering over Probability" by Rintu Nath (*Dream 2047*, December 2012). It is very well written. Concepts have been well explained and logically follow in succession. The example of coincidence of birthday in a group of 50 persons for motivating interest in the study of concepts of probability has been effectively used, as the climax of the article is the calculation of the probability for this event using the concepts which have been pedagogically developed in the text.

Well done!

A.N. Maheshwari
anmaheshwari@hotmail.com

Awesome article

The article on Srinivasa Ramanujan by Rintu Nath (*Dream 2047*, December 2012) was really awesome. The contents have been meticulously chosen and arranged so beautifully that an amateur will also relish the author's language.

Arindam Brahma
ariana.786@gmail.com

A Tale of Two Digits

I have read the article 'A Tale of Two Digits' by Rintu Nath in *Dream 2047* (November 2012). I must say it was very good. I am a software engineer, yet I found it quite interesting. Hope we will get lots of good articles from the author.

Chakresh Sahu
chakresh_sahu@yahoo.com

Rashtriya Vigyan Chalchitra Mela and Competition (RVCM) – 2013 and CSIR-OSDD-VP Short Video Competition

During the 100th Indian Science Congress, Vigyan Prasar in association with National Council of Science Museums (NCSM) organised the Third National Science Film Festival (Rashtriya Vigyan Chalchitra Mela and Competition) at Science City, Kolkata, from 4 to 7 January 2013. Science City provided local support and helped in coordination of the programme. The competition had four major categories; (a) Popular Science Film (duration more than 20 m), (b) Short Film on Science and Technology (duration less than 20 m) and (c) Animation/ Graphic Special Effects in Science & technology film/video; and (d) Science & Technology Film made by student (s). There was also a Special Jury Award.

This year's competition attracted outstanding science and technology video films produced in the country to set a new bench-mark for excellence. There were 83 entries received in different categories. Out of these, 9 films were in the 'Popular Science Film' category; 11 in the 'Short film on science and technology' category; two in the 'Animation/ Graphics & Special Effects in science and technology film or video' category; and three in the 'Science & Technology Film made by student(s)' were shortlisted. The films under different categories for awards were selected by a national jury. The team was lead by Mr Amol Palekar the well known film personality, while Dr Saroj Ghose, former DG, NCSM, Mr Subhash Joshi, Rt. Scientist from ISRO, Mr Vivek Apte, EMRC, Pune were the other members. Dr Arvind C Rande, Scientist, VP was the member convener of the jury.

The Third Science Film Festival was inaugurated on 4th January by Mr Amol Palekar and Director General of National Council of Science Museums Mr G.S. Rautela. Dr R. Gopichandran, Director, Vigyan Prasar spoke about the initiative and future direction while Dr Arvind C. Ranade, Scientist from Vigyan Prasar, briefed about the programme.

This year, Vigyan Prasar jointly with Council of Scientific and Industrial Research (CSIR) and Open Source Drug Discovery (OSDD) consortium has started a new

competition of video clips up to 5 minutes long on the topic "*The need of new drug for tuberculosis*" uploaded on YouTube. For this

competition, more than 180 entries were received of which 23 were awarded prizes. The screening of 23 short videos of CSIR-

The award winners

Category I: 'Popular Science Film'

Golden Beaver Award

Film Title : The Night Warriors
Directed by : S. Balamurudan
Produced by : Centre for Electronics Media, Pondicherry University



Silver Beaver Award

Film Title : You Can Prevent Cancer of Cervix
Directed by : Dr. Parvez Imam
Produced by : Dr. Parvez Imam



Bronze Beaver Award

Film Title : The Voice of Life: Acharya J.C. Bose Part 1
Directed by : Matiur Rahman
Produced by : Vigyan Prasar

Category II: 'Short Films on Science & Technology'

Golden Beaver Award

Film Title : Ladakh's Artificial Glaciers
Directed by : Rajendra Kondapalli
Produced by : Pulse Media Pvt. Ltd.

Silver Beaver Award

Film Title : Sparrows/ Gorraiya
Directed by : K. Prabhakar Iyyer
Produced by : K. Prabhakar Iyyer



Silver Beaver Award

Film Title : Magic of 110: Daytime Astronomy
Directed by : Seema Muralidhara, H. Muralidhara
Produced by : Vigyan Prasar



Bronze Beaver Award

Film Title : Captive breeding & Cage Farming of Karimeen
Directed by : Antony N Felix
Produced by : Monsoon Productions Anathanam Studios



Category III: 'Animation and Graphics Films on Science & Technology'

Bronze Beaver Award

Film Title : Nisarg Runa (Nature's Loan)
Directed by : Shrikant Agawane
Produced by : Shrikant Agawane



OSDD-VP competition was conducted at seminar hall in Science City on 6 January. Prof. Sameer Brahmachari, DG, CSIR was present during the screening and delivered a talk to the participants of the function.

Award presentation ceremony was held in Mini Auditorium, Science City, on 7 January. Mr Amol Palekar was the Guest of Honour and Prof Sameer Brahmachari was the Chief Guest at the function. Mr A D Chaudhari, Director, Science City, Dr B.C Bhat of IIA, Bangalore, Dr Vandana Gurmude of ARI, Pune, Dr Zakir Thomas of OSDD, Delhi, and Dr R Gopichandran, Director, VP were the other special invitees. The awards were presented to winners under different categories while shortlisted films were given the certificate of merit.

(Report by: Dr. Arvind C. Ranade)

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

Golden Beaver Award

Film Title : An Apple
Directed by : John Benedict Julius
Produced by : Satish Narayanan, Big Aims
(Reliance Animation)



Special Jury Award

Film Title : Tiger Dynasty
Directed by : S. Nallumuthu
Produced by : BBC Natural World

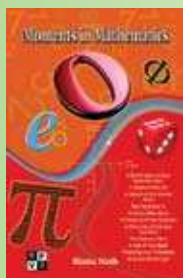


Special Jury Award

Film Title : The Green Wish
Directed by : Satish Pande
Produced by : Comfed Productions Pvt. Ltd.



Recent Publications of Vigyan Prasar



Moments in Mathematics

Author: Rintu Nath
ISBN: 978-81-7480-224-8
Price: 110/-

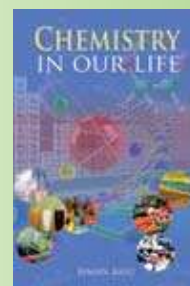
We encounter mathematics in our everyday life in different forms. It also plays a predominant role in an overall development of the society. An understanding and appreciation of mathematics is therefore an essential life skill. While it helps solve many real-life problems, it makes it possible to develop a logical thinking process. The concepts of mathematics are unravelled through a conversation between young Googol and his uncle, who explains intricacies of mathematical issues in this book and motivates him to ask more questions. The conversation is often witty and unfolds the mystical and the wonderful world of mathematics in an entertaining style. This book will take the reader to the beautiful and mesmerising world of mathematics.

contains interviews with some of the key personnel connected with this programme.

Chemistry in Our Life

Author: Biman Basu
ISBN : 978817482216-3
Price: ₹ 150/-

Although most of us don't realise it, chemistry is all around us. Right from the moment we get up in the morning till we go to bed at night, we come intimately close to chemistry and things related to it. A world without chemistry would be a world without cooking gas, beautiful dyes, or synthetic materials and many others. This book presents a few examples to bring out the magic inherent in chemistry, as visible in the colours of nature, the taste and flavour of foods, the healing power of medicines, the sparkle of festival fireworks, and the multitude of industrial processes that would be impossible without chemistry.



Mars Beckons India: The Story of India's Mission to Mars

Author: Srinivas Laxman
ISBN 978-81-7480-225-5
Price: ₹ 175/-

India is slated to launch an unmanned mission to Mars by October-November 2013, and currently preparations are in full swing for this flight at various ISRO centres. The book is basically an exercise in public outreach about this mission and attempts to explain to the reader, the significance about this project. It

Chinu Visits Microworld

Author Dr. Yeshwant R. Waghmare
ISBN 978-81-7480-213-2
Price: ₹ 150/-

The author has made an attempt to explain some interesting phenomena, such as variety of colours that we see in nature, and why and how they occur. It is pointed out in this book that all phenomena that we see in nature arise from the interactions of atoms and molecules of various species; and their combinations. The author takes the reader 'back in time' and allows interacting with them, and their inventors, through their representative CHINU, a curious little girl at the school level.



For further more information please write to:



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