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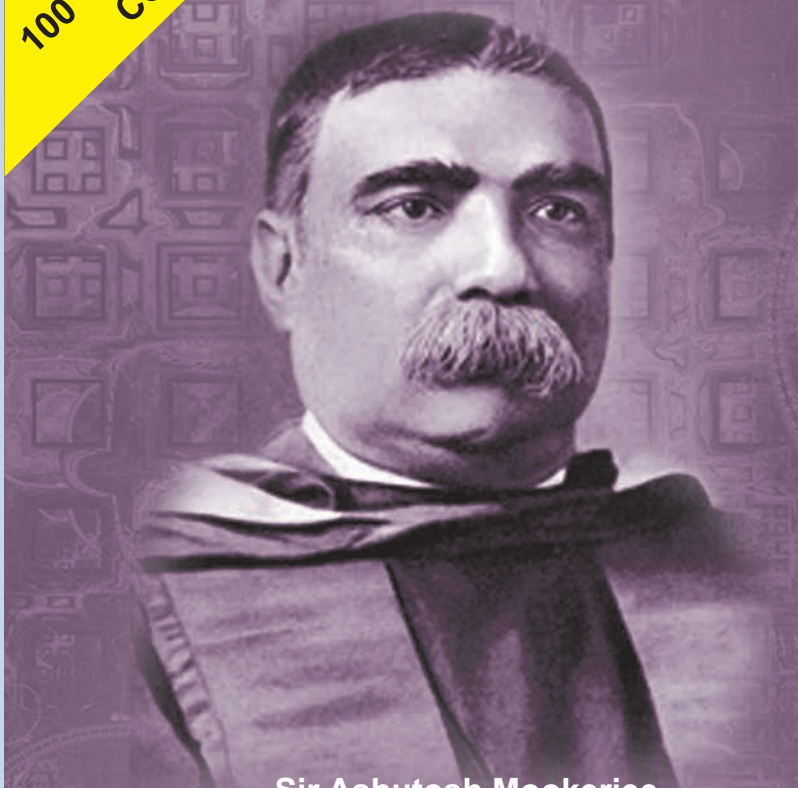

Sir Ashutosh Mookerjee

The Prime Connection

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

Enabling circumstances essential for success of communication for compliance

Dr. R. Gopichandran

It is well known that clear empirical evidences pertaining to pollution impacts establish the context for strict enforcement of compliance norms. These evidences appeal to the logic of the links between the causes of perturbations and the nature and scale of impacts. However, the preparedness of the polluters to comply is often determined by such aspects as the costs of compliance and access to alternatives in addition to their technical abilities to use the alternatives successfully. Ozone layer protection is a typical case in point.

Enablers should be mutually reinforcing guided by tangible indictors of progress. There are valuable lessons from the development and implementation of the Montreal Protocol for Protection of the Ozone Layer regarding the links between perceiving an environmental problem and focussed action to actually tackle challenges posed by the problem. A snapshot analysis of the process reveals that scientific temper signified by incisive and consistent interpretation of observations pervaded all aspects of the Protocol. These pertain to the physical and chemical correlates of the actual reduction in the levels of ozone in the stratosphere and the occurrence and influence of radicals that destroy ozone. Extensive and latitude-specific measurements of ultraviolet radiation corroborate these observations and guide remedial measures.

The impetus to prevent depletion and help ozone layer recover is, however, sustained through ground level enablers. There are five types of enablers. These include well defined and verifiable impacts of the following:

i. Regulations that have inbuilt compliance monitors for countries to abide by;

ii. Rewards and penalties for countries for compliance and otherwise, respectively;

iii. Rewards for citizens for using alternatives;

iv. Fiscal and non-fiscal measures that help industry change over to alternatives; and

v. Institutional mechanisms that ensure flow of appropriate information in a timely manner aligned with the goals of the Protocol.

Information supports capacity building for citizens through a real-life connect. The most important connect is between the levels of ultraviolet radiation and its impact on human health, including the development of cataracts and non-melanoma skin cancer and hence the need to use materials that contain only alternatives that do not deplete the ozone layer. Consumer products that contain alternatives are encouraged to highlight the benefit of using the alternative and in this process also support a global cause. These are seen especially in the case of propellants, foams, refrigeration and air conditioning systems in the market.

The link between ozone-depleting impact of chlorofluorocarbon based refrigerants in the stratosphere and their global warming impacts while in the troposphere are well-known. This called for a suitable communication strategy that highlighted the twin-benefits of using alternatives, through which climate and ozone layer issues are tackled simultaneously. At the next level of convergence of issues and opportunities to tackle them, the Indian market, as in several other countries, has imbibed the link between energy-efficient equipment that use alternatives and the twin advantages stated above. These reinforce the real-life connect and hence the opportunity to deliver tangible benefits of global environmental protection through locally relevant and timely action.

The small and medium enterprises, in particular, are trained in the use of alternatives in their products and production systems. Nationwide training and capacity building programmes in India through the Industrial Training Institutes and industry associations are aimed at helping industry stakeholders learn about the use of alternatives. Efforts to infuse learning materials and objectives at the school and higher education levels are also in progress.

Scientific evidences with a real-life connect certainly set the context for rapid and verifiable action. These have to be collated and organised for ready use. Information on the use of alternatives and systems that ensure easy access are essential to sustain transitions. Capacity-building of producers and appropriate information on choice that can be used by the consumers reinforce abilities of stakeholders to act in a concerted manner. These enablers serve the larger purpose of stimulating the innate scientific temper in citizens to comprehend issues and options. Interestingly, the open-endedness of a continually evolving understanding of issues and options helps leapfrogging into regimes of alternatives that serve multiple environmental goals of common good. It will be useful to establish such systemic synergies with respect to many other challenges too through issue-specific adaptation of these enablers. The expected launch of India's 12th five-year plans and India's national missions aimed at climate-resilient action set the context for such integrated interventions.

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Asima Chatterjee

First Woman General President of the Indian Science Congress

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"The endeavour of scientists, teachers, and all those who in one way of other are engaged in the pursuit of science, should be to help not only the students but also the people at large, to understand the value of such pursuit. The facts of history and also the requirements of scientific progress will point to the supreme need for promoting the public understanding of science. The success of this effort will depend on our sincerity and zeal as also the depth of team spirit with which we would address ourselves to this enlightened task."

Asima Chatterjee in her General Presidential address to Indian Science Congress (1975)

"… all efforts to develop Science and technology will be futile if human implications of science are not given due consideration… the aim of Science and technology is not only to meet the materialistic needs of the country but also to create a better world with higher objectives and with a conception of global community. The time has come for nations to act in this vision."

Asima Chatterjee in her General Presidential address to Indian Science Congress (1975)

"Asima Chatterjee achieved success against heavy odds due to her exemplary indomitable spirit, total commitment, strong will, hard work and an insatiable urge for the pursuit of knowledge. Her philosophy and work culture can be summed up by her own statement in an interview with a Bengali weekly about 30 years ago: 'I wish to work as long as I live', a promise she kept by letter and spirit. … A large number of students obtained PhD and DSc degrees under her guidance and supervision. However, to my mind, her best contribution to Indian science was that she could establish a school of Natural Products Chemists to carry forward her legacy in India and abroad in the universities, research institutions and industry."

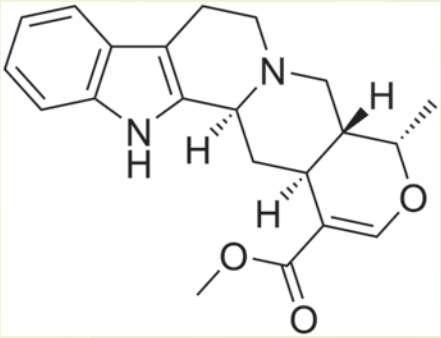
S.C. Pakrashi a well-known natural products chemist and who was a PhD student of Asima Chatterjee

Asima Chatterjee was a pioneer woman scientist of India. She was the first woman to be awarded the Doctorate of Science (DSc) degree by an Indian University in 1944 and the first woman scientist to occupy a Chair in an Indian university. She was also the first woman General President of the Indian Science Congress (1975). Her research career spanned over five decades. She published over 350 research papers in Indian and foreign journals and guided over 50 PhD students. She is best known for her significant work in the field of natural products, especially alkaloids (see Box), coumarins (a group of plant-derived polyphenolic compounds) and terpenoids (probably the most widespread group of natural products – a subclass of the prenylipids), derived from Indian medicinal and other plants. Her works have been widely quoted and some of her important works have become part of textbooks related to her fields of work. Her pioneering work on indole alkaloids made considerable impact on subsequent research in this field in India and abroad. She established a school of natural products chemists in India.

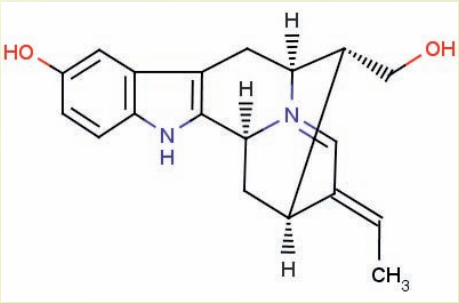
Asima Chatterjee

Chatterjee started her research career in 1938 when she initiated her chemical investigations on the indole alkaloids of *Rauwolfia canescens*. She studied almost all the principal types of indole alkaloids. Chatterjee's studies contributed greatly to the elucidation of the structure and stereochemistry of ajmalicine and sarpagine.

Rauwolfia canescens, *the first medicinal plants to be studied by Chatterjee*



Molecular structure of ajmalicine



Molecular structure of sarpagine

In fact it was Chatterjee who first suggested the correct stereo-configuration of sarpagine. One of her important achievements was the isolation and characterisation of geissosehizine, a key product in the biogenesis of indole alkaloids from *Rhazya stricta*.

Chatterjee also worked on the chemistry of steroidal alkaloids. She carried out the synthetic studies of a number of alkaloids. One of her notable achievements of her synthetic work was the stereo-specific synthesis of rauwolscine, the major alkaloid of *Rauwolfia canescens*. To achieve the synthesis of this alkaloid she developed a simple procedure for the preparation of the required beta-phenylethanolamines.

She made significant contribution to the chemistry of terpenoids. For studying terpenoids, she thoroughly examined over a dozen of plants including *Aphanamixis polystachya*, *Walsura tabulata*, *Cedrela toona*, *Zanthoxylum rhetsa*, *Artemisia vulgaris*, *Croton caudatus* and *Callicarpa macrophylla*. She studied extensively the transformation of terpenoids and established the correlation of terpenoids of different structures through Lewis acid catalysed rearrangements. This was a novel work and led to a better understanding of the structural relationships of the terpenoids.

Chatterjee's work on the chemistry of coumarins was also of high significance. Her work on coumarins started with the elucidation of the structure of luvangetin isolated from *Luvunga scandens*. She and her group isolated a large number of coumarins bearing interesting substitution patterns from Indian medicinal plants belonging to the families *Rutaceae*, *Umbelliferae*, *Compositae*, *Euphorbiaceae* and *Thymelaeaceae*. She made extensive studies on the action of various Lewis acids on prenylated coumarins and devised simple synthetic routes to a number of complex coumarin systems.

BOX : Alkaloids

The use of alkaloids or more precisely alkaloid-containing plants by human beings has a history of more than 3,000 years. The use of the latex of opium poppy was in vogue in the Middle East around 1200 BC. Socrates, the Greek philosopher, was punished to death by drinking an extract of coniine-containing hemlock in 339 BC.

Alkaloids are a group of natural products. Most alkaloids contain one or more nitrogen atoms. Most alkaloids in their pure forms are colourless, non-volatile, crystalline solids. Almost all alkaloids have a bitter taste. Alkaloids are primarily found in plants. More than 4,000 plant species have been identified which produce alkaloids. Alkaloids are also produced by bacteria, fungi and animals. Alkaloids have diverse physiological effects on humans and other animals. Many alkaloids have pharmacological effects and are used as medications.

The name "alkaloid" (alkali-like) was coined by the German chemist Carl F. W. Meissner in 1819. The scientific study of alkaloids began after the isolation of morphine by Friedrich Serturner in 1806 from opium. Serturner named "morphium" after the name of the Greek god of Dreams, Morpheus. This name is still being used in some languages including German. It was the French physicist Joseph Louis Gay-Lussac who gave the name "morphine". Following the discovery of morphine more than 12,000 alkaloids have been isolated. Some of the important alkaloids which were discovered after the discovery of morphine were: xanthine (1817), strychnine (1818), atropine (1819), quinine (1820), caffeine (1820), coniine (1827), nicotine (1828), colchicine (1833), sparteine (1851), and cocaine (1860).

The first alkaloid to be synthesised was the piperidine alkaloid coniine, which is extremely toxic, causing paralysis of motor nerves. Coniine was synthesised by the German chemist Albert Ladenburg in 1886.

Alkaloids display great structural diversity. It has proved to be a difficult proposition to develop a uniform classification system for alkaloids. An alkaloid is named by adding the suffix "ine" to the species or genus name of the plant from which the alkaloid is derived. Common examples are atropine (isolated from the plant *Atropa belladonna*) and strychnine (obtained from *Strychnos mux-vomica L.*). When one single plant is the source of several alkaloids then their names often contain suffixes "idine", "anine", "aline", "inine", etc. The names of at least 86 alkaloids extracted from the Vinca plant contain the root "vin".

Chatterjee also worked in mechanistic organic chemistry. She thoroughly investigated the mechanism of the acid-catalysed hydramine fission of phenylethanol. She developed a method for detecting and locating double bonds in organic compounds by using periodic acid (H_5IO_3). This method was a good alternative to ozonolysis.

Chatterjee and her group developed the anti-epileptic drugs, Ayush-56 from *Marsillea minuta* and an anti-malarial drug from *Alstonia scholaris*, *Swertia Chirata*, *Picrorhiza kurroa* and *Caesalpinia crista*. These drugs were patented and they were developed by several companies.

Like other scientists of her time Ashima Chatterjee had to struggle a lot to establish herself as a researcher. In this context it is important to note the comments of one of her early PhD students S. C. Pakrashi: "Being one of her early PhD students I have closely witnessed her initial struggles to establish herself. Those were trying days for research, particularly in the most ill-equipped university laboratories with inadequate chemicals and meagre financial assistance. DST and DBT were yet to come and CSIR was in formative stage. Research guides had often to pay not only for chemicals, apparatus, etc., but also the charges of even elementary and almost all spectral analyses to be had from abroad. Scholarships were few and barely enough; most of the students had to work and pay all the necessary cost of thesis submission including printing, examination fee and even the postal charges for dispatching the thesis to foreign examiner (s), which was compulsory, with hardly any job prospect for research as a profession. Before I joined her, she had grant of Rs 300/- p.a. and three college teachers as part time students."

Asima Chatterjee was born on 23 September 1917 in a middle class family of Bengal. She grew up in Kolkata. After completing her school education she entered the Scottish Church College of the Calcutta University from where she graduated with Honours in chemistry in 1936. She obtained her MSc degree from Calcutta University in 1938, majoring in organic chemistry. She got her DSc degree from the Calcutta University in 1944. Her research guide was P.K. Bose, a pioneer in natural products chemistry in India. Her thesis was on the chemistry of plant products and synthetic organic chemistry. Her thesis was examined and highly spoken by A.R. Todd, Nobel Laureate. It has been reported that she imbibed interest in medicinal plants from

her father Indra Narayan Mukherjee, a medical man-cum-amateur botanist. Her husband Baradananda Chatterjee, an accomplished physical chemist, was the Vice Principal of the Bengal Engineering College (now a deemed university).

In 1940, Chatterjee joined Lady Brabourne College as the Founder Head of the Chemistry Department. In 1944, she was appointed as an Honorary Lecturer in chemistry of the Calcutta University. In 1947, she went to USA where she first worked with L.M. Parks at the University of Wisconsin on naturally occurring glycosides and then with L. Zechmeister at the California Institute of Technology, Pasadena. At the California Institute of Technology she worked on carotenoids and pro-vitamins. In 1949 she went to the University of Zurich to work with the Nobel Laureate Paul Karrer and where she worked on biologically active alkaloids. She returned to India in 1950.

P.K. Bose, Chatterjee's research guide

Paul Karrer, the Nobel Laureate with whom Chatterjee worked in Zurich

Chatterjee left Lady Brabourne College in 1954 to join the Department of Chemistry in the University College of Science, Calcutta University, where she worked till the end of her active academic career. She was appointed as Khaira Professor of Chemistry, one of the most prestigious and coveted chairs of Calcutta University. She occupied this Chair till 1982.

Chatterjee revised, updated and edited the *Bharatiya Banashoudhi*, a six-volume treatise on Indian medicinal plants, published by Calcutta University during 1973-1977. The treatise was originally edited by K. P. Biswas. She was the Chief Editor of the six-volume *Treatise on Medicinal Plants* published by Council of Scientific and Industrial Research. The six-volume treatise described seven hundred medicinal plants.

Chatterjee was very closely associated with the Indian Science Congress. She served as its General Secretary and Treasurer for a term of three years each. She was elected its General President for three years 1974-75. Besides being a professor of Chemistry, Chatterjee served the Calcutta University in many ways. She served as a member of the University Senate as also of the Syndicate. She was associated with the academic council and Board of Studies in chemistry.

She played an instrumental role in establishing a Regional Research Institute for carrying out research on Indian medicinal plants for the development of Ayurvedic drugs. The institute was established under the aegis of the Central Council for Research in Ayurveda and Siddha in Salt Lake, Calcutta through unique centre-state collaboration. An Ayurvedic Hospital was also established as part of the institute for systematic clinical trials. Chatterjee was made Honorary Principal co-ordinator and in this capacity she nurtured the institute till the end of her life.

Chatterjee was a highly dedicated teacher and researcher. She cared for the well-being of her students. One of her research students S.C. Pakrashi, commenting on her influence on students wrote: "…I joined Chatterjee's group in 1952 as a PhD student … It was not easy those days to carry out research in ill-equipped university laboratory and with meagre funds and hardly any prospect of research as a profession. Still she could motivate, inspire and instil in her students the sense of commitment, integrity, sincerity, tenacity and all the essentials of a good research worker by her own example. As a teacher she was never satisfied with the performance so far as work was concerned. As a human being she was kind hearted and understanding. She would go out of her way to help not only her own associates, but anybody who would approve her."

Asima Chatterjee was of the opinion that the university research has a central role in the development of science and technology. Once, emphasising the role of universities in maintaining the students and technology in the country she said: "Since the universities are the backbone of scientific and technological training and the university research still forms the 'spear-head' of scientific progress and provides a reasonably good barometer of the standard of science and technology in the country, the universities should receive the high national priority. In a developing country like India, the strengthening of the universities is of paramount importance. The experience of more than a century has already proved that teaching and research flourish in combination, but in isolation they wither. The best of either is achieved in an environment where both are cultivated *pari passu*. In this combination of teaching and research, education and discoveries lies the real strength of the universities. If research in these academic institutions is poor and neglected, research outside these centres cannot flourish for any length of time. It has been said that a research institution, no matter — under what auspices – will seldom last a generation as a creative enterprise, if it has no continuing (effective) contacts with young research students. This underscores the central role of university research in national development and the extreme importance of close links between universities and research institution including the National Laboratories and industries."

In 1960, Chatterjee was elected a Fellow of the Indian National Science Academy, New Delhi. She was awarded the *Shanti Swarup Bhatnagar Prize* in 1961. Among other awards received by her were: *Nagarjuna Award and Gold Medal* of Calcutta University (1940), *Premchand Roychand Studentship* of Calcutta University (1942), *Mouat Medal* of Calcutta University (1944), *Sir P. C. Ray Award* of the Indian Chemical Society (1974), *Sir C. V. Raman Award* of the Hari Om Trust by the University Grants Commission (1982), *Professor P. K. Bose Award* of the Indian Chemical Society (1988), *Sir Asutosh Mookerjee Memorial Gold Medal* of the Indian Science Congress Association (1989). She was elected as Woman of the Year by the Bengal Chambers of Commerce (1975). The Government of India conferred

Continued on page 27

The Prime Connection

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Recently my uncle got engrossed with the cases of Sherlock Holmes, the famous fictional detective created by the author and physician Sir Arthur Conan Doyle. Holmes was a London-based consulting private detective who is famous for his incisive and intelligent logical reasoning and forensic science skills to solve criminal cases. It was therefore not a surprise that these days my uncle kept asking me questions using his characteristic cryptic clues about facts related to Sherlock Holmes stories.

One evening, he told me that Holmes was featured in four novels and 56 short stories. The first novel, *A Study in Scarlet*, appeared in Beeton's Christmas Annual in 1887. All but four stories on Holmes are narrated by Holmes's friend and biographer, Dr Watson; two are narrated by Holmes himself (*The Blanched Soldier* and *The Lion's Mane*) and two others are written in the third person (*The Mazarin Stone* and *His Last Bow*). Conan Doyle wrote the first set of stories over the course of a decade. To devote more time to his historical novels, he wrote *The Final Problem* in 1893 when Holmes presumably died after the fall over Reichenbach Falls while fighting with his greatest opponent Professor Moriarty. After resisting public pressure for eight years, he brought back Holmes in *The Adventure of the Empty House*.

'Google, could you tell me which Sherlock Holmes' stories or novels had the following numbers in the title: 2, 3, 4, 5 and 6?'

'I can say, at least two of them. The number 4 appears in the second novel *The Sign of the Four*. The number 5 is in the story titled *The Five Orange Pips*.'

'That's a good attempt, Googol. Let me give you the other answers. For the number 2, it's *The Adventure of the Second Stain*. There are at least three stories with number 3 in the titles. These are: *The Adventure of the Three Students*, *The Adventure of the Three Garridebs*, and *The Adventure of the Three Gables*. Finally, the number 6 appears in the title *The Adventure of the Six Napoleons*.'

'Yes, I read some of those stories,' I replied.

'Which address is also referred to as the world's most famous address?' uncle asked.

'It's 221B, Baker Street, London. It's the apartment where Sherlock Holmes lived.' I gave a quick reply.

'Fantastic, Googol. Do you know that this is indeed a real address in London? The complete address is: 221B Baker Street, London, NW1 6XE, England. According to the stories written by Sir Arthur Conan Doyle, Sherlock Holmes and Doctor John H. Watson lived at 221B Baker Street between the years 1881 to 1904. The house is now protected by the government due to its special architectural and historical interest, while the first floor study overlooking Baker Street is still faithfully maintained for the posterity as it was kept in Victorian Times.'

'That's amazing, Holmes is immortalised at 221B Baker Street. Uncle, is there anything special with the number 221?'

'Hmm, it's an interesting question. The number 221 is indeed a very fascinating number. I'll tell you more about this later. For the time being, I can say that the number 221 is a composite number which is the product of two prime numbers: 13 and 17.'

'Uncle, we earlier discussed about the prime number and composite number. May I jog my memory on this?'

'Yes, please Googol. Tell me what you know about the prime number and composite number.'

'A *prime number*, or a prime, is an integer greater than 1 that can be divided only by itself and 1. A natural number greater than 1 that is not a prime number is called a *composite number*. For example, 5 is a prime, as it is divisible by only 1 and 5, whereas 6 is composite, because it has the divisors 2 and 3 in addition to 1 and 6.'

'This division between prime and composite numbers turns out to be one of the cornerstones of mathematics, and is a characteristic which is used in mathematical proofs over and over.'

'Uncle, I remember that you told me that there are *an infinite number of primes* or the sequence 2, 3, 5, 7, 11, 13, ... of prime numbers never ends. I also learnt that the number *1 is not a prime number* and the number *2 is the first prime number* and it's also the only *even prime number*; *all other prime numbers are odd*. The number *zero is neither a prime nor a composite number.* You also told me that all composite numbers formed by multiplying primes.'

'Are there limited number of prime numbers in number world?' I wanted to know.

'No. In fact, there are an infinite number of primes. Another way of stating this is that the sequence 2, 3, 5, 7, 11, 13, ... of prime numbers never ends. Most of the unsolved mysteries in mathematics are also related to prime numbers.'

'Is number 1 a prime?'

'*1 is not a prime number*. 2 is the first prime number and the only *even prime number*; *all other prime numbers are odd*,' uncle replied.

'Is zero a prime?' I wanted to know.

'It's a very good question, Googol. It is interesting to know that *zero is neither a prime nor a composite number*. It cannot be a prime because it has an infinite number of factors. It is not a composite number because it cannot be expressed by multiplying prime numbers. 0 must always be one of the factors.'

'Are all composite numbers formed by multiplying primes?'

'Yes. Let me explain. If we factorise a composite number into two smaller numbers, then it needs to be checked whether these two numbers are themselves primes or composites. For example, 6 factorises into 2 x 3. Both the numbers 2 and 3 are prime numbers. The number 18 factorises into 2 x 9. Here the number 2 is a prime but the number 9 is not. However, the number 9 factorises into 3 x 3 and the number 3 is a prime. Hence the number 18 can be written as 18 = 2 x 3 x 3. Any composite number, no matter how large, can be factorised into two smaller numbers. We then ask whether each of the smaller factors is a prime or composite. If either one is composite, we factorise it again. The process continues till all the factors are primes. This in itself is interesting and leads to a fascinating conclusion. When a composite number is factorised into primes, those primes are *unique* to that number. For

example, we can factorise the number 30 into 2 x 3 x 5. No other set of primes, when multiplied together, will yield 30.'

'This is very interesting, uncle!'

'One of the building blocks of mathematics is that *every whole number greater than 1 can be expressed as a product of prime numbers in one and only one way*, which has come to be known as the fundamental theory of arithmetic.'

'I understand now why the number zero cannot be a composite number. The number zero can be expressed as 0 = 0 x 2 x 3 or 0 = 0 x 7 x 17 or infinitely many different ways. A composite number can be expressed as a product of prime numbers in one and only one way. Hence the number zero cannot be a composite number. At the same time zero has infinite numbers of factors. Hence it cannot be a prime. However, I'm still unclear why 1 is not a prime. Could you explain this to me?'

'If 1 is considered a prime, then the fundamental theory of arithmetic breaks down! Because 30 = 2 x 3 x 5 and also 30 = 1 x 2 x 3 x 5. Hence factorisation of 30 will not be unique. Therefore, 1 is not a prime number,' uncle replied.

'Please tell me more about prime numbers. They seem to have many fascinating properties.'

'Prime factorisation is the key to all e-commerce applications, where financial transactions are done over Internet.'

'Please tell me more on this, uncle,' I said.

'When we exchange secret data, like bank account information, password, etc., there is a chance that a third person may intercept the data and may try to take undue advantage out of it. To protect secret data, *Public Key Cryptographic System* (PKCS) was developed. The system is based on prime numbers.' My uncle explained.

'Please tell me how prime numbers are able to protect secret data,' I wanted to know.

'Take two very large prime numbers, say P1 and P2. Multiply P1 and P2, say you get N, where N = P1 x P2. If I give you N and ask you to find P1 and P2, it would be difficult for you to find P1 and P2. Here P1 and P2 are unique to N, called *prime factors*. For example, consider P1 = 53 and P2 = 59, then, N = 53 x 59 = 3127. It is easy. However, if I give you 3127, and then ask you to find its prime factors, it would take some time before you get the answer. Using a computer program will be helpful. However, if P1 and P2 are very big prime numbers, say 150 digits each, then even a computer will take substantially long time to get the prime factors. This is the basis of PKCS.' Uncle explained.

'I always wanted to know how e-commerce transactions take place over Internet. It seems mathematics is the answer!'

'Yes Googol. Before PKCS was invented, secret communication used to take place using secret codes. For example, if person *A* wants to send confidential data to another person *B*, both *A* and *B* will share the same secret code. *A* will encrypt the data using the secret code and *B* will decrypt using the same secret code. In its simplest form, say, *A* wants to send bank account number "1789" to *B*. *A* encrypts "1789" by multiplying it by 7, i.e., *A* sends "12523" to *B*, who already knows that 7 is the secret key. On receiving "12523", *B* will divide it by 7 and gets back the original number. However, the drawback of such system is that if *B* receives such communication from multiple persons, multiple secret codes will be required. It is analogous to buying a separate lock and key for each transaction. If *B* has done 10 transactions, *B* will need 10 keys. *B* has to protect and manage all 10 keys. Think about another situation, where *B* has only one key and multiple similar types of locks. *B* distributes these locks to all he/she wants to do transactions and keep the key with him/her. Everybody will encrypt the secret data using the lock *B* has provided and send it back to *B*. Now, as *B* has the key, only he/she will be able to decrypt all information. Note, *B* has to protect and manage only one key. Isn't it simpler?'

'Uncle, please elaborate how these lock and keys are implemented in mathematics.'

'PKCS is based on a pair of keys, called *private key* and *public key*. Public key is analogous to lock and private key is the secret code, as I have just explained. Secret information is encrypted using *public key* and decrypted using *private key*. PKCS is implemented mathematically using an algorithm, called RSA algorithm, named after its inventors Ron Rivest, Adi Shamir and Leonard Adleman.'

'How are private and public keys generated and how are prime numbers involved?' I wanted to know.

'Suppose *B* takes two primes *P1* and *P2*. Multiply *P1* and *P2* to get *N*, *N* = *P1* x *P2*. Now, *public key* is (*N, e*), where, *e* is a small *public exponent*. This *public key* of *B* is known to everyone. *Private key* is (*N, d*) and is known to *B* only. Here, *d* is another number calculated from *P1* and *P2* using some mathematical function. Consider *A* has to send secret information '*m*' to *B*. *A* will encrypt '*m*' using the *public key* (*N, e*). Let '*c*' be the encrypted data, derived from '*m*', *N* and *e*. *B* will receive '*c*'. Using the *private key* (*N, d*), *B* will be able to decrypt the secret information '*m*'.'

'Uncle, I have a question. When *A* is sending '*c*' to *B*, there is a possibility of an unauthorised person intercepting it. Can that unauthorised person decrypt the secret code if he/she has the *public key*?'

'Googol, the public key is available to everybody, including the unauthorised third person. However, the encrypted data '*c*' can only be decrypted by the private key, which is known only to *B*.' Uncle replied.

'Is it possible to guess the private key from the public key? After all, both the *private key* and the *public key* are generated from two prime numbers *P1* and *P2*.' I wanted to know.

'It is almost impossible to guess. If *N1* and *N2* are large prime numbers, even a supercomputer will take thousands of years to guess *private keys* from *public key* and the *encrypted data*. Therefore PKCS is very safe.'

'But I have heard about fraudulent practices over net banking and similar e-commerce transactions! How is it possible?' I wanted to know.

'These do not happen due to failure of PKCS. RSA algorithm can never fail to provide adequate security. All the fraudulent practices that are reported are due to careless mistakes of the people involved in it – like sharing user ID, password, etc.'

'Thank you for explaining. Coming back to our Sherlock Holmes query, tell me more about the special features about the number 221?' I asked.

'In mathematics, a *semiprime* (also called *biprime* or *2-almost prime*, or *pq number*) is a natural number that is the product of two (not necessarily distinct) prime numbers. As I mentioned before, 221 is the product of two prime numbers, 13 and 17. So, 221 is a semiprime number.

Continued on page 25

Menacing plastic pollution:
A challenge to the gen-next


Dipanjan Ghosh
Sreeparna Ghosh

Plastic is intricately related to our day-to-day life. However, the throw away culture has created an almost irreversible situation with plastic pollution, which poses numerous hazards related to both environment and health. To cope with such situation, innovative policies are urgently needed.

With the advancement of science and technology in the last century, it has been possible for people to lead life with ease. Technological boom has given birth to newer things, the importance of which is limitless in our daily life. Plastic is such a wondrous material. In every sphere of our life – from agriculture, industry, transport, medicine, sports, and entertainment to space technology – the use of plastics is ubiquitous. But extensive use of plastics has also led to a nagging environmental problem.. The main problem with plastic waste is its long durability and non-biodegradability, making it remain in the environment almost forever.

Chemistry of plastic

Polymer is a macromolecule composed of repeating structural units or 'monomers'. In Greek '*poly*' means 'many' and '*meros*' means 'part'. The term 'polymer' was coined by Jons Jacob Berzelius in1833. A polymer actually encompasses a large class of compounds comprising both natural and synthetic materials with a wide variety of properties. In this sense many natural things such as silk, wool, cotton, jute, rubber, shellac, etc., are polymers. Plastics are also polymers and thus the term 'polymer' is often taken to refer to plastics.

A plastic is any of a wide range of synthetic or semi-synthetic organic solids that are mouldable by application of heat or pressure. Plastics are typically organic polymers of high molecular weight which do not break apart when flexed. They are mainly composed of polymers of carbon and hydrogen, which may also contain oxygen, nitrogen, chlorine, sulphur and even silicon as supplements. Usually plastics are synthetic, most commonly derived from petrochemicals, but many are partly natural.

Plastics are broadly classified into two categories – thermoplastics and thermosetting polymers. Thermoplastics include polyethylene, polystyrene, polyvinylchloride and polytetrafluoroethylene. These are the thermolabile substances; i.e., if enough heat is applied, thermoplastics will soften and melt. On the other hand, thermosetting plastics are heat stable compounds and cannot be melted or reshaped once they are solidified.

Early history

Early plastics were exclusively biological materials such as egg and blood proteins, which are organic polymers. Materials that resemble the properties of cattle horns were developed by treating casein (milk-proteins) with lye (strong solution of sodium or potassium hydroxide) in the Middle Ages for making lanterns. However, the development of synthetic plastics accelerated with Charles Goodyear's discovery of vulcanisation in 1839, as a route to thermoset materials derived from natural rubber. In 1907, Bakelite, the first fully synthetic thermoset polymer was reported by Belgian chemist Leo Baekeland. Later in 1927, world's second best-selling plastic polyvinylchloride (PVC) was developed by Waldo Semon, an American chemist associated with B F Goodrich Company. Consecutively, polystyrene or Thermocol, a recyclable thermoplastic (or sometimes a thermoset material) was discovered in 1937. Polypropylene is a thermoplastic polymer that was developed in 1957. Within this period, three important plastic polymers, namely polythene or polyethylene (most variedly used plastic), polytetrafluoroethylene or teflon (chiefly used in the preparation of non-stick coating in cookware), and silicone (a familiar material for present day cosmetic surgery) were discovered through individual efforts as well as by groups of chemists associated with some multinational companies.

Plastics are everywhere

Plastics are durable, light, easy to mould, and can be adapted to different user requirements. With its exclusive qualities of being light yet strong and economical, plastics have changed life styles and convenience in home, cutting across every strata of society – from ball pens to bangles, from refrigerators to water filters, from ubiquitous buckets to thermowares. They have made life easier, better and happier for our homemakers. Plastics reach out to millions of people every day. From groceries to drinking water and from oil to farm freshness, all are wrapped in plastics. Polystyrene is used for making combs, buttons, umbrella-hilt, toys, and many other things, whereas polyvinylchloride is used for plumbing, gutters, house siding, doors and windows, floor mats, shoe soles, rain coats, as well as in insulation for electrical

Plastics have countless uses in modern civilisation world over.

Plastic pipes and containers are used for transporting and storing water.

Table 1: Source of generation of waste plastics	
Household	Carry bags, Bottles, Containers, Trash bags
Health and Medicine	Disposable syringes, glucose bottles, Blood bags, intravenous tubes, catheters, surgical gloves.
Hotel and Catering	Packaging items, mineral water bottles, plastic plates, glasses, spoons
Air/Rail Travel	Mineral water bottles, plastic plates, glasses, spoons, plastic bags

cables. Soft PVC is made by adding organic phthalates and phosphates to vinyl chloride that is used in food packaging, soft toys, clothing and so on. Again, extremely strong, shock absorbing as well as elastic plastic has been introduced for making body parts of speedy bikes and cars.

The use of plastics haverevolutionised the field of medicine and health care,, making patients safer and procedures simpler. A large number of clinical and surgical appliances such as disposable syringes, blood pouches and, intravenous tubes, catheters, surgical gloves, cardiac valves, hips and knee joints, and artificial limbs, etc., are made of plastics. Plastic polymers used in all these aforesaid materials are free of any side effects, as they do not react with blood and body fluids of patients. Side by side, all these materials are cheap, unbreakable, rust-free, and inert in nature and can easily be moulded into any shape.

In India, the plastic industry is growing phenomenally. Plastics have use in all sectors of the economy – infrastructure, construction, agriculture, consumer goods, telecommunications, and packaging. However, today the use of plastics is not restricted to these sectors only. New innovations in the field of plastic technology is inspiring new hopes. Now a kind of absorbent plastic has been developed that can absorb and retain large amounts of water. Such plastic polymers are used for making diapers for babies. This invention opens up the possibility of cultivation in dry desert conditions. Crops have been successfully grown by watering the plants in drops at the roots by using this absorbent polymer. There has been revolution in electrical and telecommunication industries where metal wires have been replaced by optical fibres. Even plastics have been invented that can conduct electricity and in some cases, the conducting ability of these plastics is greater than copper wires.

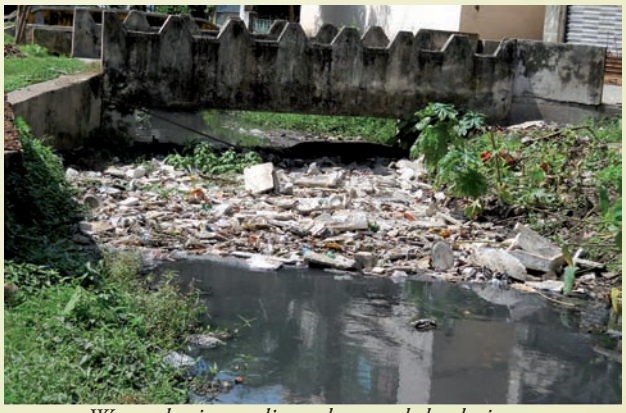
Garbage heaps dominated by plastics present an ugly and unhygienic situation.

Plastic hazards

Plastics are so widely used that their impact on the environment and human health are extremely wide ranging. Most of the petrochemical-based plastics are non-biodegradable. Moreover, the present day throw away culture results in the production of huge amount of waste plastics each year (Table 1). A major portion of this garbage remains strewn on the ground, littered around in open drains, or in unmanaged garbage dumps. Waste plastics find their way into the city streets, parks and gardens, riverbanks, sea beaches and even on the mountains or other tourist spots. Careless disposal of plastic bags chokes drains, blocks the porosity of the soil and causes problems for groundwater recharge. The blockage of drainage systems cause inconvenience, difficulty in maintaining the drainage, and above all creates unhealthy environment resulting in health hazard and spread of water-borne diseases. Plastic disturbs the soil microbe activity and the soil fertility eventually deteriorates. Plastics also cause choking hazards for cattle that ingest plastic bags or other items accidentally during feeding. Plastic bags can also contaminate foodstuff due to leaching of toxic dyes and transfer of pathogens.

Conventional plastics have been associated with reproductive problems in both wildlife and humans. Studies have shown a decline in human sperm count and quality, genital abnormalities and a rise in the incidence of breast cancer. Burning of plastics, especially PVC, releases toxic compounds like dioxin and also furan into the atmosphere. PVC burning also generates hydrogen chloride. Because hydrogen chloride readily combines with water vapour in the air to form hydrochloric acid, PVC burning is very much harmful to both human health and the environment.

Some plastics contain a variety of toxic additives like adipates, phthalates, etc. Recent



Waste plastics are littered around the drainage system causing health problems.

Once ingested, plastics can kill animals.

studies have shown that reuse of bottles made of polyethylene terephthalate (PET) can in fact be dangerous. PET is found to breakdown over time and leach phthalate as well as antimony (Sb) into the beverage when the bottles are reused. The toxin bis (2-ethylhexyl) adipate or DEHA also appears in water sample stored in recycled PET water bottles. DEHA has been shown to cause liver abscess, leukaemia, endocrine system disruption, and other possible reproductive problems and is suspected to cause cancer in humans.

Managing plastic pollution

Yet plastics in general are not toxic materials but it is their non-degradable nature that generates pollution. Plastics cause disposal problems, incineration or recycling being the only available option. The plastic industry in the developed world has realised the need of environmentally acceptable modes for recycling plastics wastes and has set out targets and missions. Prominent among such missions are the Plastic Waste Management Institute in Japan, the European Centre for Plastics in Environment, the Plastic Waste Management Task Force in Malaysia. Manufacturers, civic authorities, environmentalists, and the public have begun to acknowledge the need for plastics to conform to certain guidelines or standards and code of conduct for its use.

But the good news is that India is not far behind in the matter of plastic recycling. Along with a growth in the use, a country-wide network for collection of plastic waste through rag pickers, waste collectors, waste dealers and recycling enterprises has sprung all over the country in the last decade or so. More than 50-70 per cent of the plastic waste generated in our country is recycled and used in the manufacture of various plastic products.

Tailpiece

Now the question is how to cope with plastic pollution. It is needless to say that enacting laws against the excessive use of plastics or socially boycotting plastics is no longer a permanent solution. But instead of throwing away plastic-made things after use, we can make those things useful by recycling process. However, some plastics cannot be recycled or incinerated due to pigments or other additives. Again, burning up of plastic is harmful to both human health and the environment whereas recycling is a cumbersome process. So, then what is the solution? Designing eco-friendly, biodegradable plastics are the need of the hour. Though partially biodegradable plastics have been developed and used, completely biodegradable plastics based on renewable starch rather than petrochemicals have only recently been developed and are in the early stages of commercialisation.

Apart from teaching, Dipanjan Ghosh is an well-known popular science writer. Presently the number of published article is near about 200. He is also involved in popularization is science, organizing science fairs, nature watch camps and radio talks. E-mail to: dpanjanghosh@gmail.com for sharing your views.

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Continued from page 32 (**Asima Chatterjee: First Woman General President of the Indian Science Congress**)

on her the prestigious civilian award *Padma Bhushan* in 1975. Chatterjee was nominated by the President of India as a member of the *Rajya Sabha* (Upper House of India Parliamet) which she served from February 1982 till May 1990.

Chatterjee emphasised the importance of cultivating the scientific way of thinking or scientific temper among the common people of the country. She thought that the Indian Science Congress can and should play an effective role in this important task. In her Presidential Address to the Indian Science Congress she said: "…scientific way of thinking, if properly cultivated, would help secure for the people of the country all the benefits of progress in science and technology. But dissemination of scientific knowledge must not be limited to urban areas. It should be extended also to people in villages in an effective manner. In this field the Indian Science Congress could play an effective role as well. More widespread and systematic dissemination of scientific information is sure to educate public opinion."

Chatterjee died on 23 November 2006 in Kolkata at the age of 89.

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Centenary session of Indian Science Congress

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The Indian Science Congress has taken forward India's heritage of research and discoveries in science and technology since 1914. Year 2013 is the centenary year of Indian Science Congress with the theme "Science for shaping the future of India". There is no doubt that the centenary celebration of the Indian Science Congress will be a great event in the history of Indian science.

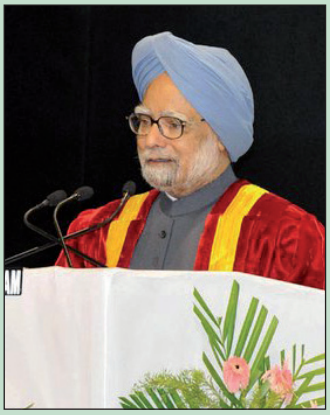
Indian Science Congress Association (ISCA) is the foremost and the premier organisation representing India's scientific fraternity. ISCA was established to stimulate scientific research in India. It is one of the oldest scientific organisations in the country which has played a very significant role in shaping Indian science. The centenary celebration of the Indian Science Congress provides a unique opportunity to know more about this great institution.

The Indian Science Congress is one of the greatest annual events of the Indian scientific community and is attended by over 15,000 delegates. It comprises technical sessions, panel discussions, public lectures, a vision tour, the 'Pride of India' expo, and the genesis symposium. The centenary session is expected to serve as a platform for coming together of all stake holders of science and society to pave a new path of progress for the country in the emerging global knowledge economy.

During the centenary year, the Indian Science Congress Hall of Pride will celebrate the life and achievements of the first prime minister of India, Pandit Jawaharlal Nehru, who was the general president of the Indian Science Congress in 1947, as well as the life and achievements of the first general president of Indian Science Congress, Sir Ashutosh Mukherjee.

Kolkata will host the 100th Indian Science Congress. Incidentally, Kolkata also hosted the 1st Indian Science Congress in 1914. Prime Minister Dr. Manmohan Singh is the General President of the 100th session. He is the first Prime Minister to be elected General President of ISCA. While speaking at the inception ceremony of the ISCA centenary held in Kolkata on 2 June

General President's message for the 100th Science Congress



It is an honour and a privilege for me to assume the position of the General President of the Indian Science Congress Association in its centennial year. I have received this honour with deep humility towards the scientific community and accepted this challenge with a profound sense of responsibility towards the teeming millions of our country, for whom science could be a force of transformation from poverty, ignorance, hunger and disease.

The Indian Science Congress Association was conceived a hundred years back by visionary leaders of Indian science. It reflected the spirit of the times and the values of self-reliance and nationalism. Luminaries like J.C. Bose, C.V. Raman, S.N. Bose, Srinivasa Ramanujan, Meghnad Saha and many others made a global name despite the tremendous odds they faced. Indian science and scientists of every generation have carried forward the glorious tradition established by these legends, exploring fields of scientific enquiry that were considered the preserves of the developed world. I salute their achievements.

Today, the challenge lies in harnessing the potential of science in rendering services to our nation and humankind as a whole. Resource constraints have often hampered our ability to mobilize scientific talent and apply scientific findings to our specific requirements. Thanks to the sustained high economic growth over the last few decades, the dreams of Indian science could now take wings. It is imperative for the community of scientists to remain rooted to our reality and be cognizant of our own problems, to make inclusive growth and development a reality. I hope the centenary celebration of The Indian Science Congress Association will also be an occasion to recall the social consciousness that inspired the founding fathers of the Association. This is why the theme chosen for the Science Congress for the year 2012-13 is "Science for Shaping the Future of India".

The 100th annual session of the Congress has been convened in Kolkata between 3 and 7 January, 2013. This is the city where the journey began for the Association. We have just celebrated the 150th anniversary of its two iconic sons, Gurudev Tagore and Acharya P.C. Ray – one a humanist and the other a scientist – who in their own ways represented the zeitgeist associated with the Science Congress movement. The legacy of the movement connects the 100th session to Kolkata and the Calcutta University. Its homecoming will give us an opportunity to re-live the history of the movement.

I am deeply indebted to the Council of the Association and the Advisory Council, who are working tirelessly to give shape to our vision for Indian science. We should observe the centenary year in the most productive and purposeful manner.

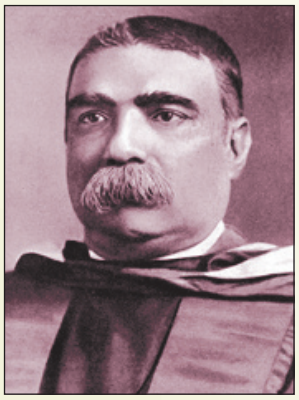
I invite the scientific community of India to come out and shape the future of modern India. I extend a warm welcome to all those who would participate in the Centenary Year events of the Indian Science Congress.

[Source: http://www.isc2013.in]

2012 the Prime Minister expressed the hope that "scientists would use the centenary year celebrations to reflect on how we can frame a science and technology policy that reflects our aspiration for making science a spearhead of development in our country".

The centenary of the India Science Congress needs to be utilised by all to create an interest in science, particularly among the youth, to enhance the public appreciation of the significance of science in their daily life and to spread scientific temper in all sections of the society as visualised by Pt. Jawaharlal Nehru, the first Prime Minister of India.

Sir Ashutosh Mookerjee



Ashutosh Mookerjee was one of the architects of Modern India. He was an eminent mathematician, jurist, and educationist. Mookerjee is mostly known for his pioneering role in broadening the scope of higher education in the country. As Vice Chancellor of Calcutta University he played a pioneering role in encouraging post-graduate teaching and research in science. He changed the very direction of Calcutta University. He integrated teaching and research at the University level for the first time in India.

Ashutosh Mookerjee presided over the first Indian Science Congress in 1914, held on the premises of the Asiatic Society, Kolkata. Commenting on the object and scope of the Indian Science Congress Association in his Presidential address, he had stated that ISCA was formed "…..to give a stronger impulse and a more systematic direction to scientific enquiry, to promote the intercourse of societies and individuals interested in science in different parts of the country, to obtain a more general attention to the objects of pure and applied science and the removal of any disadvantages of a public kind which may impede its progress."

Pandit Jawaharlal Nehru

The 34th Annual Session of the Indian Science Congress was held at Delhi during 3-8 January 1947, presided over by Pandit Jawaharlal Nehru. He was the then Vice-President of the Interim Government. Addressing the Congress, Pandit Nehru declared, "Science in India too is coming of age; it would try to solve the problems of the New India by rapid, planned development of all sectors and try to make her more and more scientifically-minded."

Pandit Nehru's personal interest in the Science Congress continued and there has been hardly any session which he did not attend. He has immensely enriched the activities of the Congress by his sustained interest in the development of scientific atmosphere in the country, particularly among the younger generation. In fact, since 1947, inviting representatives from foreign societies and academies has been a regular feature of the Science Congress. This trend still continues with the support of the Department of Science & Technology, Government of India. ■

Continued from page 30 (The Prime Connection)

Examples of a few other semiprime numbers are: 4, 6, 9, 10, 14, 15, 21, 22, 25 and 26.'

'That's very fascinating indeed. What are the characteristics of the semiprime numbers?'

'The square of any prime number is a semiprime, so the largest known semiprime will always be the square of the largest known prime, unless the factors of the semiprimes are not known. As you could guess, based on the Mersenne prime, the largest known semiprime is $(2^{43112609} - 1)^2$, which has over 25 million digits. Like prime numbers, the semiprime numbers are also very important for cryptography and number theory.'

'It's not a wonder that 221B Baker Street had the most worthy inhabitant there – Sherlock Holmes.'

'The number 221 also has other attractive features. It's also the sum of five consecutive prime numbers (37 + 41 + 43 + 47 + 53 = 221) and the sum of nine consecutive prime numbers (11 + 13 + 17 + 19 + 23 + 29 + 31 + 37 + 41 = 221).'

'That's amazing, uncle! After knowing about the prime numbers and Holmes, I was thinking how the modern day Holmes will look today.'

'Go on Googol.'

'Apart from his immense knowledge on botany, geology, anatomy, chemistry and forensic science, Holmes is a cryptography specialist as well. He reads the morning newspaper, browses the Internet, tweets, texts and blogs regularly. Taking the cues from the modern day technologies, he solves the cases in his mind in no time. I am though not sure how much he likes to be in the glare of social or electronic media!'

'It's elementary, my dear Googol,' uncle said in a tone similar to that of Sherlock Holmes. ■

Award

Honourable President of India Shri Pranab Mukherji, on the occasion of Hindi Divas Samaroh (14 Sept. 2012) at Vigyan Bhawan, New Delhi delivering "Rajiv Gandhi Rashtriya Gyan-Vigyan Puraskar" to Vigyan Prasar's Manish Mohan Gore (left) and Navnit Gupta (right). This award is given by Rajbhasha Vibhag of the Home Ministry for original science books in Hindi language.

Chronic Myeloid Leukaemia Understanding the Basics

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Leukaemias are a group of bone marrow cancers. Characterised by a large increase in the cancerous white blood cells, which multiply uncontrollably, the abnormal white cells flood the bone marrow, where all types of blood cells are normally produced. This reduces the usual production of normal white blood cells, normal red blood cells, and platelets in the bone marrow.

Each of these derangements have a striking effect on health. While a reduction in the number of red blood cells reduces the oxygen-carrying capacity of blood, the lowering of white blood cells opens the body to a serious risk of infections, and diminished platelets can result in abnormal bleeding.

Types of leukaemia

Broadly, leukaemias are categorised into acute leukaemia, in which the symptoms develop rapidly, and chronic leukaemia, in which the symptoms can take years to develop. Adults may develop either type of leukaemia, but children usually have the acute form.

Depending upon the type of white blood cell which has become cancerous, acute leukaemias are again divided into acute lymphoblastic and acute myeloid leukaemia. Chronic leukaemia also takes two forms: chronic lymphocytic, and chronic myeloid leukaemia.

Acute leukaemias affect immature cells; the disease develops rapidly, with symptoms including anaemia, fever, bleeding, and swelling of the lymph nodes. Immature leukaemia cells continue to divide in the bone marrow, which leads to rapid death if left untreated.

In chronic leukaemia the cells develop and are transported to the tissues, but the cells do not function normally.

Chronic myeloid leukaemia

Chronic myeloid leukaemia is the commonest type of blood cancer found in India. Characterised by infiltration of the blood, bone marrow, and other tissues by abnormal white blood cells, the disease may happen at any age. Still, it most commonly occurs in people between 30-60 years of age. Rarely, it may also affect children. Both men and women can develop the disease, though men outnumber women by 1.7 times.

Causes

The cause of chronic myeloid leukaemia is not known. In almost all people who have the disease, however, the cancerous cells contain an abnormal chromosome. This odd chromosome is called the 'Philadelphia chromosome'.

The human cells each contain 23 pairs of chromosomes that are made of DNA and hold the instructions for every cell in the body. The Philadelphia chromosome forms when chromosome 9 and chromosome 22 break and exchange portions. This creates an abnormally small chromosome 22 and a new combination of instructions for the cells that can lead to the development of chronic myeloid leukaemia.

Risk factors

Some factors are known to increase the risk of chronic myeloid leukaemia. These factors include:

- Older age
- Being male
- Radiation exposure, such as radiation therapy for certain types of cancer

Family history is, however, not a risk factor. The chromosome mutation that leads to chronic myeloid leukaemia is not passed from parents to offspring. This mutation is believed to be acquired, meaning it develops after birth.

Symptoms

There are two phases of chronic myeloid leukaemia. In the first, or chronic, phase, lasting for about 3 to 5 years, the symptoms develop slowly and are often mild. In the second, or acute, phase, symptoms of the disease become more severe.

The clinical onset of the chronic phase is generally quiet. Some patients are diagnosed, while still asymptomatic, during health-screening tests. Others present with fatigue, malaise, and weight loss or have symptoms resulting from splenic enlargement, such as early satiety and left upper quadrant pain or mass. Less common are features related to white blood cell or platelet dysfunction, such as infections, thrombosis, or bleeding. Occasionally, patients present with more dramatic manifestations due to severe increase in white blood cells or blood clotting with features such as blocks in blood vessels, brain stroke, heart attack, venous thrombosis, persistent painful erection of the penis (priapism), visual disturbances, and lung insufficiency.

Progression of disease is associated with worsening symptoms. Unexplained fever, significant weight loss, increasing dose requirement of the drugs controlling the disease, bone and joint pain, bleeding, thrombosis, and infections suggest transformation into accelerated or blastic phases. Less than 10–15 per cent of newly diagnosed patients present with accelerated disease or with de novo blastic phase CML.

The signs and symptoms of chronic myeloid leukaemia may include:

Easy fatigability

When diseased white blood cells crowd out the healthy red blood cells, anaemia develops. This makes a person feel tired and worn down. S/he may develop pale skin, and shortness of breath. When a

person is given treatment for chronic myeloid leukaemia, then also it can produce a drop in red blood cells.

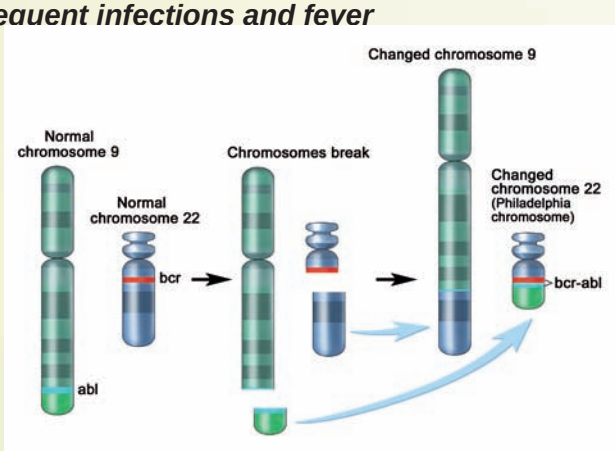
Fullness below the ribs on the left side due to the enlarged spleen, resulting in loss of appetite and weight loss

Some of the extra blood cells produced when a person has chronic myeloid leukaemia are stored in the spleen. This can cause the spleen to become swollen or enlarged. Rarely, the spleen becomes so large that it is at risk of bursting. More commonly, the swollen spleen takes up space in the abdomen and makes a person feel full even after small meals or causes pain on the left side of the body below the ribs.

Night sweats

A person with chronic myeloid leukaemia may also complain of sweating excessively during sleep. However, by itself, this symptom is not specific to the disease. Night sweats are also common in tuberculosis.

Frequent infections and fever



White blood cells help the body fight off infection. Although people with chronic myeloid leukaemia have too many white blood cells, these cells are often diseased and don't function properly. As a result, they aren't able to fight infection, unlike the healthy white cells. In addition, treatment can cause the white cell count to drop too low (neutropenia), also making a person vulnerable to infection.

Abnormal bruising and easy bleeding

Blood cells called platelets help control bleeding by plugging small leaks in blood vessels and helping the blood to clot. A shortage of blood platelets (thrombocytopenia) can result in easy bleeding and bruising, including frequent or severe nosebleeds, bleeding from the gums, or tiny red dots caused by bleeding into the skin (petechiae).

Bone and joint pains

A person with chronic myeloid leukaemia can also suffer bone pain or joint pain. This happens as the bone marrow expands when excess white blood cells build up.

Stroke or excess clotting

Some people with chronic myeloid leukaemia produce too many platelets. Without treatment, this high platelet count (thrombocytosis) can cause excessive clotting of the blood, which can lead to stroke.

Going to the doctor

Start by making an appointment with your family doctor or a general practitioner if you have any signs or symptoms that worry you. If blood tests or other tests and procedures suggest leukaemia, your doctor may refer you to a specialist, called hematologist, who is an expert in the treatment of blood and bone marrow diseases.

In the meantime, avoid anything that makes your symptoms

worse. For instance, if you feel fatigued, rest as much as possible. Focus on only the essential tasks of each day. The nonessential tasks can wait for a later day.

If you're having trouble eating because you feel full very quickly, choose smaller, more frequent meals.

Tests and diagnosis

Doctors carry out a variety of tests and procedures to diagnose the disease. These may include:

Clinical examination

The doctor will first examine the patient and check such vital signs as pulse and blood pressure. He or she will also feel for enlarged lymph nodes, spleen and abdomen for abnormalities.

Blood tests

A complete blood count (CBC) may reveal abnormalities in the blood cells. Blood chemistry tests to measure organ function may also reveal abnormalities that can help the doctor make a diagnosis.

Bone marrow tests

Bone marrow biopsy and bone marrow aspiration are used to collect bone marrow samples for laboratory testing. These tests involve collecting bone marrow from the hipbone.

Tests to look for the Philadelphia chromosome

Specialised tests, such as fluorescence *in situ* hybridisation (FISH) analysis and polymerase chain reaction (PCR) test, analyse blood or bone marrow samples for the presence of the Philadelphia chromosome or the BCR-ABL gene.

(Next month: Ways to Win over Chronic Myeloid Leukaemia)

Top 10 science stories of 2012

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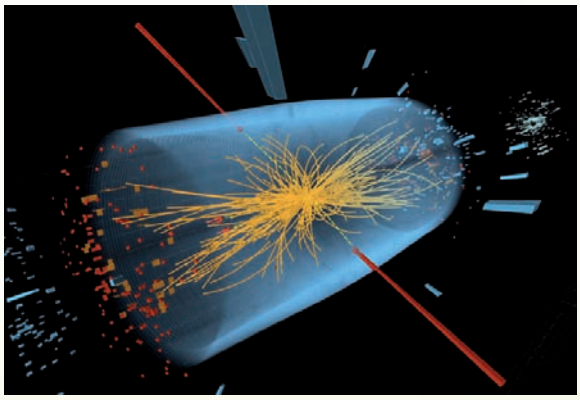
1. Higgs boson discovered

Discovery of the long sought-after subatomic particle called the Higgs boson on 4 July 2012 in experiments conducted at the Large Hadron Collider at CERN was



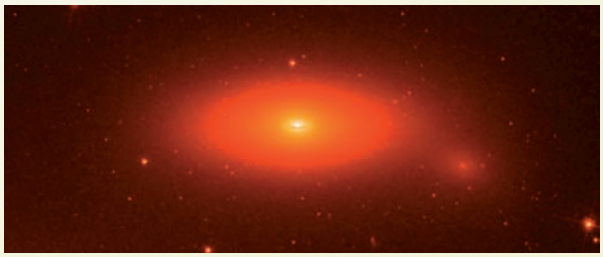
the culmination of more than five decades of search for the elusive particle. After analysing trillions of high-energy proton-proton collisions, signals corresponding to a boson in the mass region 125-126 GeV, as predicted for the Higgs boson, were recorded by both ATLAS and CMS detectors of the LHC.

Higgs boson was postulated as the carrier particle, or boson, of the Higgs field, a theoretical field that permeates space and endows all elementary subatomic particles with mass through its interactions with them. The field and the particle – named after Peter Higgs of the University of Edinburgh, one of the physicists who first proposed this mechanism – provide a testable hypothesis for the origin of mass in elementary particles.

The historic discovery of the Higgs particle has a significant India connection. As many as 17 Indian scientific institutions including Raja Ramanna Centre for Advanced Technology in Indore, Institute of Physics in Bhubaneswar, Panjab University, Universities of Guwahati and Rajasthan, Saha Institute of Nuclear Physics, Variable Energy Cyclotron Centre, and Bose Institute in Kolkata, and IIT, Mumbai have supplied vital parts including magnets and detectors for the LHC as well as developed software for analysis of the data.

2. Most massive black hole

Hundreds of black holes have been discovered till date, but the most recent discovery beats them all in mass. The discovery of a gargantuan black hole – with a mass17 billion times that of the Sun – was announced in November by a group of astronomers led by Remco van den Bosch from the Max Planck Institute for Astronomy (MPIA) in Heidelberg, Germany. The team used archival data from the Hubble Space Telescope and observations from the Hobby-Eberly Telescope in Fort Davis, Texas, which focussed on the most massive galaxies in the nearby Universe. The black hole was found in a galaxy identified as NGC 1277, some 250 million light years away in the constellation of Perseus. According to the astronomers, the discovery could upset the accepted relationship between black hole mass and galaxy mass, which plays a key role in all current theories of galaxy evolution.



The most surprising fact about the newly discovered black hole is that its mass is too large compared to the mass of the whole galaxy, contradicting a widely accepted view about the growth of galaxies. Most large galaxies harbour giant black holes at their centres. The Milky Way's central black hole, for example, weighs 4 million times as much as the Sun. But such black holes usually obey a standard correlation: typically, the black hole mass is a tiny fraction of the galaxy's central bulge. The recent finding is contrary to previous estimates based on observations of some 70 other galaxies with central black holes, which indicate that a supermassive black hole typically has about 0.1% the mass of its home galaxy's stellar bulge. In comparison, the black hole in NGC 1277 is about 59% as massive as the galaxy's central bulge of stars.

3. The *Curiosity* Mars mission

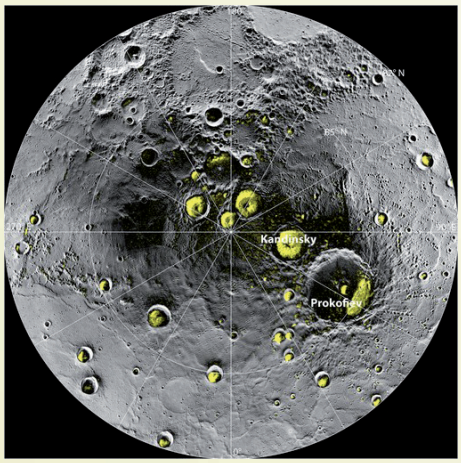
The US space programme crossed a significant milestone on 6 August 2012 with the perfect landing of the Mars rover *Curiosity* on Mars. The landing of the 900-kg rover, the heaviest yet to be landed on Mars, was different from all previous Mars missions in many ways. For the first time, rockets were used and a huge parachute was deployed to slow down the landing craft as it entered the Martian atmosphere. Finally, NASA used a unique 'sky crane' to soft land the rover gently on the floor of the Gale Crater on Mars. Apart from being much larger and heavier than any previous Mars lander, *Curiosity* uses the heat of decaying radioactive plutonium rather than solar cells as the source of power, which is expected to provide high power levels, day and night, for much longer than *Curiosity*'s mission life.

Known as Mars Science Laboratory, the mission was launched in November last year. The basic objective of the mission is to seek evidence whether Mars ever hosted ingredients for life. *Curiosity* look for organic molecule in the Martian soil and rocks, by scooping up soil and drill through Martian rocks using laser, to determine the Martian environment over geological time scales – going back to 4 billion years – and search for hints of organic compounds and elements essential to life.

Since its dramatic landing in inside Gale Crater in July, *Curiosity* has returned more than 23,000 raw images; driven 517 metres, and begun helping researchers better understand the area's environmental history. In December mission scientists announced that *Curiosity* has found evidence of chlorine, sulphur and water as well as "hints of organic compounds which could aid primitive life". During a two-year prime mission, researchers will be using *Curiosity*'s ten science instruments to assess whether the study area in Gale Crater ever has offered environmental conditions favourable for microbial life.

4. Mercury has ice in craters

Mercury, the first planet from the Sun, is the second hottest planet, with a daytime surface temperature of a blistering 400°C.



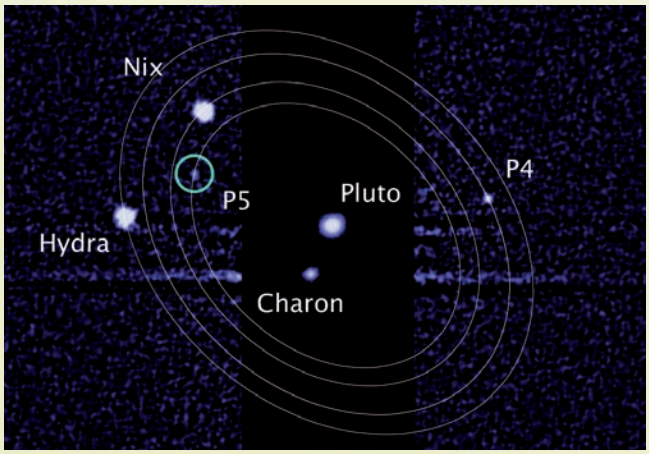
But NASA's orbiting *MESSENGER* probe has recently found evidence of water ice on the planet. According to scientists working on the *MESSENGER* mission, as much as 1.1 trillion tonnes of ice – enough to fill 20 billion Olympic skating rinks – could be trapped inside Mercury's polar craters that never see sunlight. According to the scientists, much of the ice may be protected by a dark layer of carbon-rich organic material several centimetres thick, and the water and organic material probably are not native to Mercury; it could have been delivered by icy comets as they smashed into the surface. The discovery was announced in November in the journal Science.

Planetary scientists had strong hints of presence of ice on Mercury a couple of decades ago when telescopes bounced radio waves off Mercury and the reflections were surprisingly bright. But some researchers suggested the craters could be lined with silicate compounds or sulphur, which might also be highly reflective. *MESSENGER* has now cleared the doubt. Now it is known that although at noon at the equator on Mercury, the temperature can rise to 400°C, near Mercury's poles, deep within craters where the Sunlight never reaches, temperatures dip to as low as minus 223°C.

The *MESSENGER* spacecraft, which has been in orbit around Mercury since March 2011 and has completed its primary mission, took a closer look by counting neutrons ejected by rocks on the planet. High-energy cosmic rays hitting the surface of Mercury break apart atoms, and the debris includes neutrons, which *MESSENGER* can detect. But when a speeding neutron hits a hydrogen atom, which is almost the same weight, it comes to almost a complete stop. Water molecules contain two hydrogen atoms, and so stop more neutrons. Thus when *MESSENGER* passed over ice-rich areas, the number of neutrons dropped. The same technique was used to detect frozen water below the surface on Mars and within similar craters on the Moon.

5. Pluto's fifth moon discovered

A fifth moon of Pluto, once considered the outermost planet of the solar system that was degraded to a "dwarf planet" status in 2006, was discovered in July. The new moon, dubbed P5 until it gets a proper name, is estimated to be irregular in shape and 10 to 25 kilometres across. Even in the Hubble's best images, the new moon – some 5.9 billion kilometres from the Sun – is visible only as a speck of light. The orbit of the new moon is still uncertain, though the tiny moon appears to be circling in the same plane as Pluto's other satellites and roughly 42,000 km from the dwarf planet. Pluto's largest moon – the 1,050-km-wide Charon – was discovered in 1978. Its two smaller moons, Nix and Hydra, were found in 2005 and a fourth moon P4 was discovered in 2011. P5 is incredibly faint – half as bright as P4, and roughly one one-hundred-thousandth as bright as Pluto – and orbits relatively close to the dwarf planet.



Pluto's new moon was discovered on 7 July 2012 by chance, in the course of checking out the potential collision hazards to NASA's *New Horizons* spacecraft, which is due for a flyby of Pluto, passing 10,000 km from the planet on 14 July 2015. According to NASA, the discovery will help the New Horizons spacecraft navigate its way to the planet safely. Moving past the dwarf planet at a speed of more than 48,000 km per hour, *New Horizons* could be destroyed in a collision with even a tiny piece of orbital debris.

6. Banana genome sequenced

An international consortium of plant scientists announced in July the completion of the first sequencing of the banana genome, which has been found to contain more than 36,000 genes, slightly more than in the human genome. The banana is the first non-grassy plant in its botanical class, the monocotyledons, or monocots, whose entire genome has been sequenced. The genome that has been sequenced ran to 523 million 'base pairs', the chemical units that make up DNA and encode the genetic information. Bananas (Musa spp.) are vital for food security in many tropical and subtropical countries and the most popular fruit in industrialised countries. It provides food and economic security for more than 400 million people in some of the poorest parts of the globe, but they are under constant threat from a range of parasites. Bananas are difficult to breed and are under attack from a host of diseases and other pests.

Knowledge of the banana genome is important because bananas that are cultivated, unlike their wild relatives, are seedless and develop without going through a

process of pollination, fertilisation and seed production. These domesticated forms are mostly multiplied by vegetative propagation, by using a part of the parent plant. As a result, the offspring are genetically similar to the parent and such similarity makes most of the present day cultivated varieties susceptible to fungal, bacterial and viral diseases. The completion of the genome sequence is important for India, which is the world's largest producer of bananas. From the knowledge of the entire genome of the plant it may be possible to identify the genes responsible for disease resistance as well as ones for other important traits such as fruit quality, which may help in breeding improved varieties of the fruit.

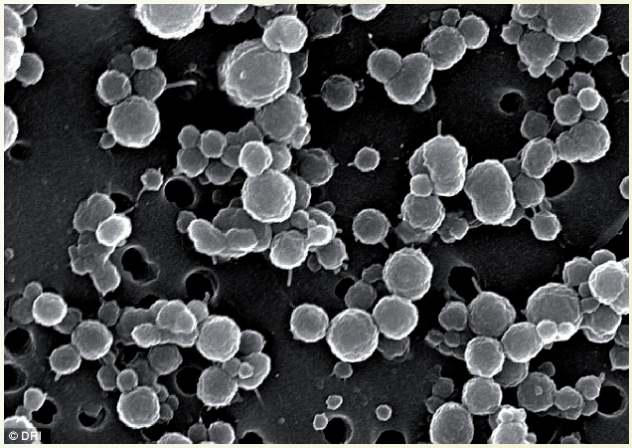
7. New species of legless amphibians

After a digging through the monsoon-soaked soils at 250 locations of remote northeast India for over five years, a team of researchers led by Sathyabhama Das Biju of Delhi University has come up with an entirely new species of legless amphibians till recently unknown to science. According to the researchers, the new species – called chikilidae – is endemic to the region but has ancient links to Africa, which shows that the species evolved much before Indian subcontinent separated from the African landmass.

Interestingly, these worm-like animals are closer to frogs than worms! The new discovery gives yet more evidence that India is a hotbed of amphibian life with habitats worth protecting. According to the researchers, Chikilidae is a group of extremely dedicated burrowers. They exhibit an intriguing and highly specialised reproductive behaviour. The mother builds underground nests for her eggs and guards her egg-clutch by coiling around them until the embryos hatch after 2-3 months.

8. Ancient microbes found in Antarctic lake

In November, a team of scientists from NASA, the Desert Research Institute (DRI) in Reno, Nevada, the University of Illinois at Chicago, and nine other institutions, announced the discovery of a community of bacteria existing in one of Earth's darkest, saltiest and coldest habitats – nearly 20 metres beneath the icy surface of a remote Antarctic lake called Lake Vida that has not seen light or oxygen for 2800 years. The surprising thing is that the lake water contains no oxygen, is mostly frozen, and possesses the highest nitrous oxide levels of any natural water body on Earth. A briny liquid, which is approximately six times saltier than sea water, percolates throughout the icy environment where the average temperature is minus 22°C. Thirty-two species of bacteria were identified. They are believed to live off chemical reactions with hydrogen in the lake water. This discovery of life existing in one of Earth's darkest, saltiest and coldest habitats is significant because it helps increase our limited knowledge of how life can sustain itself in these extreme environments on our own planet and beyond.

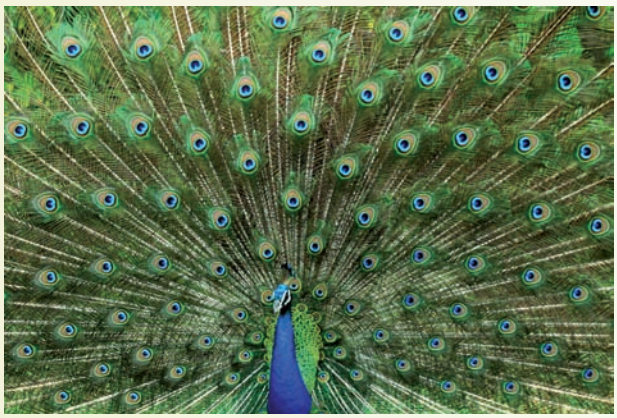


Geochemical analyses suggest that chemical reactions between the brine and the underlying iron-rich sediments generate nitrous oxide and molecular hydrogen. According to the researchers, molecular hydrogen, in part, may provide the energy needed to support the brine's diverse microbial life.

Additional research is under way to analyse the abiotic, chemical interactions between the Lake Vida brine and its sediment, in addition to investigating the microbial community by using different genome sequencing approaches. The results could help explain the potential for life in other salty, cryogenic environments beyond Earth, such as purported subsurface aquifers on Mars.

9. New light on peacock communication

We are all familiar with the loud, piercing call of the peacock, but a recent study has revealed that during courtship peacocks also use low-frequency sounds that humans cannot hear. The most attractive part of a peacock is its long tail formed of magnificent eye-spotted train feathers. Normally, peacocks communicate visually and through sound. The peacock uses its tail train in an elaborate courtship display, which includes the display of its beautiful plumage, and its familiar loud, piercing call, and a unique courtship dance. During courtship, males are known to spread out their magnificent train feathers into a fan shape and shake it vigorously, which can create a ripple moving down the sides of the array, or else it can send a shudder radiating outward from the base. During both these classic moves, all a human being hears is a leaf-like rustling. But when a research team led by Angela Freeman, a biology graduate student of University of Manitoba in Canada recorded



the sounds they discovered very low-pitched sounds, inaudible to humans and produced by vibrations of the spread-out feathers. The team discovered that when male peacocks display their feathers during courtship they also make deep rumbling sounds that are too low pitched for humans to hear.

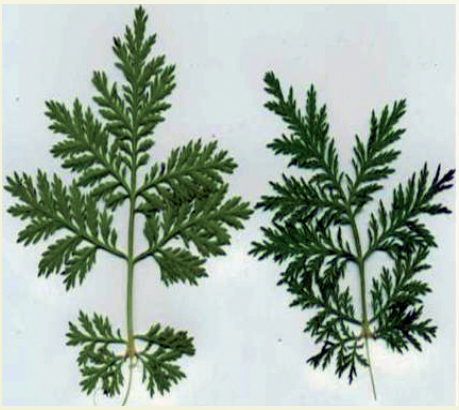
Humans can hear only within a certain range of frequencies – from 20 to 20,000 hertz (Hz). Sound of frequency below 20 Hz, known as infrasound, is inaudible to humans but can be heard by elephants whereas many animals like dogs, mice and bats can hear frequencies above 20,000 Hz, also known as ultrasound. Bird calls are of different frequencies and are used for both communication and courtship.

When Freeman played back the recorded sound to the birds, females looked alert and males were likely to come out with the familiar loud call, indicating their response to infrasound frequencies. Elephants have long been known to communicate over long distances using sound of frequency below 20 Hz. This is the first time that a bird has been shown to produce and perceive sounds below human hearing for communication.

10. Cheaper drugs against malaria

Quinine obtained from the bark of the cinchona tree was once the most effective antimalarial drug available, but it has become ineffective as the parasite has become resistant to it. The only effective antimalarial available today is artemisinin – a drug obtained from the sweet wormwood (*Artemisia annua*) plant, a herb described in Chinese traditional medicine. Since 2001, WHO has recommended that so-called artemisinin-based combination therapies (ACTs) – in which artemisinin is combined with another drug – replace older, ineffective drugs worldwide. These combinations have become a cornerstone of malaria control and are believed to have saved many lives.

But artemisinin is an expensive drug and beyond the reach of most patients in the poorer countries. ACTs still cost between $1 and $2 per treatment course, which the poor patients can hardly afford. Now there is hope for these patients. In January, scientists at the Max Planck Institute of Colloids and Interfaces in Germany developed a simple method of synthesising the artemisinin molecule, which can drastically reduce the cost of the drug. The synthetic process uses artemisinic acid, a by-product left over after extraction of artemisinin from sweet wormwood leaves. During the extraction of 1 kilogram of artemisinin, as much as 10 kilograms of artemisinic acid is produced, which is currently thrown away because its conversion into artemisinin is not cost-effective.



Two researchers at Max Planck Institute of Colloids, Peter Seeberger and François Lévesque announced in January that they have developed an inexpensive three-step continuous flow synthesis of artemisinin from artemisinic acid using a combination of oxygen and ultraviolet light. They could convert artemisinic acid into artemisinin in just four-and-a-half minutes in a continuous-flow reactor. According to the scientists, the production could be raised to 2 kg per day and when that happens the entire world's supply of the drug for a year could be produced by just 150 reactors that could cut the cost of the drug to about one-fifth its present cost.

Letters to editor

Interesting articles

I am a student of class 10 studying in Sri Aurobindo Integral School, Addada, Krishna district, A.P. I have read a few articles in your magazine Dream 2047. They are really spectacular and interesting. It is recently included in our school library. The article "How the tigers got their stripes" (May 2012) was really interesting. At a science fiction conference held at Lucknow, the science fiction writer Shukdeo Prasad, said that S.F. is not the flight of imagination. SF must have a scientific base. It is true. I hope that Vigyan Prasar sails smoothly and continues to encourage young scientists of today. I am very thankful to you for sending this magazine to our school.

P.Harshitha
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An enlightening article

First of all I would like say thanks to the editorial team for publishing Dr. M.A. Haque's informative article "The Third Pole: Must be Protected" (November 2012). The article covered a key aspect of the environment. The author has written this article very critically and gives an innovative idea about the third pole (Himalayan region covered with water, snow and ice), their significance and protection strategies. The article covered the basic idea of the Himalaya, its physical and biological environment, climatic conditions, etc., provided the information about the threat to the third pole due to global warming, and gave a detailed account about the steps taken by the government and nongovernment agencies for the protection of Himalayan regions in Indian context.

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Wanted articles on recent developments in non-conventional energy

Dream 2047 is the magazine which provides information in recent developments in science and technology. The article by Biman Basu on "Mars clay not formed of Water" (November 2012) was very amazing. I would like you to publish articles on recent developments in non-conventional energy.

Ashish Hegde
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