



DREAM 2047

September 2016

Vol. 18

No. 12

Rs. 5.00

Demystifying the Human Brain



<i>Editorial: Communication Platforms and Real Engagement Outcomes</i>	35
Walther Hermann Nernst: Discoverer of the Third Law of Thermodynamics	34
Demystifying the Human Brain	31
Himalayas with Special Reference to Indian Himalayas	29
Numbers that Hold Hands	26
Male infertility — Tests and Treatments	24
Recent developments in science and technology	21

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

Communication Platforms and Real Engagement Outcomes



Dr. R. Gopichandran

Communicators (self-styled and designated as per job!!) who claim to propagate scientific attitudes must lay their hands on a publication (National Democratic Institute 2013) I will consider classic. This is because of six insights it provides on the use of technology for engagement, and more importantly de-mystifies the link between use and impacts. The fifth and the sixth vignettes (as the summary says!) are most attractive. Pundits who cry hoarse for optimising internet-based engagement should realise, they tend to oversimplify the relationship between creating an engagement platform and “inspiring” visitors to respond in manner they wish as appropriate. Mere presence is no guarantee of visibility. The voice, space, accountability infographic is most attractive. The third of these three determinants is most important; especially because an increasingly sensitive citizenry can isolate the chaff of rhetoric from real transformations. This takes us to another realm of appropriateness of technologies that actually improve quality of life of common citizens.

The World Summit on the Information Society 2016 has created another excellent learning window about the dynamics of ICT. This is centred on UNGA Resolution 70/125, with a special emphasis on Sustainable Development Goals. Three years earlier, the Economic and Social Commission for Western Asia in its report on Citizen Engagement and the Post-2015 Development Agenda defined a well-known framework for communication. This reinforces the paradigms of communication periodically stated by the United Nations in many of its conventions and protocols and of the International Union for Conservation of Nature and Natural Resources. The central objective of this reminder is to implore communicators not to mix apples and oranges in so far as objective and communication and outcomes are concerned. The space between learning and willingness to act is quite complex and has to be tackled with credibility and patience.

I invite your attention to yet another robust knowledge resource. This is authored by Brenton Holmes (2011). Thank you Brenton for helping us know about “closing the gap” and revisit the OECD guidelines for online citizen engagement and policy making.

This editorial is basically a snapshot on high-value knowledge resources about the principles and practice of communication. Honestly, one cannot but be impressed about the spread and depth of knowledge that can be used to design and implement communication strategies. Importantly, many common purposes and barriers come to light when we examine the insights stated therein. They rightly highlight credibility as the most important determinant of success. More about credibility and being credible, soon.

References accessed on 11 August 2016

- NDI 2013 Citizen Participation and Technology 67p. <https://www.ndi.org/files/Citizen-Participation-and-Technology-an-NDI-Study.pdf>
- WSIS Forum 2016 High-Level Track Outcomes and Executive Brief https://www.itu.int/net4/wsis/forum/2016_Content/documents/outcomes/WSISForum2016%E2%80%9494HighLevelTrack-Outcomes.pdf
- Economic and Social Commission for Western Asia 2012 Citizen Engagement and the Post-2015 Development Agenda Report of the Expert Group Meeting http://www.un.org/esa/socdev/egms/docs//2013/EmpowermentPolicies/UNESCWA_Citizen-Engagement_Post-2015.pdf
- Brenton Holmes 2011 Citizens’ engagement in policymaking and the design of public services http://parlinfo.aph.gov.au/parlInfo/download/library/prspub/942018/upload_binary/942018.pdf;fileType=application/pdf#search=%222010s%22

Email: r.gopichandran@vigyanprasar.gov.in ■

Editor : R Gopichandran
Associate editor : Rintu Nath
Production : Manish Mohan Gore and Pradeep Kumar
Expert member : Biman Basu
Address for correspondence : Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi-110 016
 Tel : 011-26967532; Fax : 0120-2404437
 e-mail : info@vigyanprasar.gov.in
 website : <http://www.vigyanprasar.gov.in>

Vigyan Prasar is not responsible for the statements/opinions expressed and photographs used by the authors in their articles/write-ups published in “*Dream 2047*”

Articles, excerpts from articles published in “*Dream 2047*” may be freely reproduced with due acknowledgement/credit, provided periodicals in which they are reproduced are distributed free.

Published and Printed by Manish Mohan Gore 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 Phone: 011-26388830-32.

Walther Hermann Nernst

Discoverer of the Third Law of Thermodynamics



Dr. Subodh Mahanti

E-mail: subodhmahanti@gmail.com

'third law of thermodynamics', which states that 'the entropy of a perfect crystal is zero when the temperature of the crystal is equal to absolute zero'.

Nernst came out with this theorem while he was trying to predict the course of a chemical reaction from the measurements of specific heats and heats of reaction. In practical terms, this theorem implies the impossibility of attaining absolute zero, as a system approaches zero, further extraction of energy from that system becomes more and more difficult. Thus it can be stated that absolute zero cannot be attained in a finite number of steps. In other words, Nernst's theorem implies the impossibility of attaining absolute zero. Modern cryogenic techniques have made it possible to attain temperature less than a billionth of a degree above absolute zero, but absolute zero can never be achieved.

The third law of thermodynamics was initially used in the study of equilibrium, but later it was connected with quantum statistics. The third law of thermodynamics was essentially a derivation from the Helmholtz equation and the Thomson-Berthelot principle of maximum work.

Outlining the significance of Nernst's work, Professor Gerald de Geer, President of the Royal Swedish Academy of Sciences in his Award Ceremony Speech delivered on 10 December 1921 said: "The most significant advance which chemistry owes to Nernst's thermochemical work might in short be stated by saying that it is now possible to calculate beforehand the conditions under which a given chemical reaction will take place to the extent where a required product will be obtained in sufficient quantities to make the method of production a practical proposition. Technical difficulties can naturally appear during the course of the experiments, but it is a significant step forward to know that the aim can be achieved and that there is every chance that experiments will succeed."

Nernst argued that the third law of thermodynamics developed by him was the

"In late 1905 Nernst stated a third law of thermodynamics, which provided the means for calculating values of specific heat and for predicting the likelihood of chemical reactions from recognition that the values of entropy and specific heats approach zero at very low temperatures. Albert Einstein's quantum theory of solids, published in 1907, provided theoretical foundations for Nernst's prediction."

Mary Jo Nye in *'The Oxford Companion to the History of Modern Science'*, J.L. Heilbron (Ed.), 2003

"Nernst's widespread research in physical chemistry included much electrochemistry; the concept of solution pressure is due to him and much of the thermodynamic treatment of electrochemistry, as well as contribution to the theory of indicators and buffer action. In photochemistry he proposed the now familiar path for the fast reaction between hydrogen and chlorine..."

The Cambridge Dictionary of Scientists (2nd edition), 2003

Walther Hermann Nernst was one of the geniuses of early-twentieth century German chemistry. He was a pioneer of physical chemistry. He was awarded the 1920 Nobel Prize in chemistry 'in recognition of his work in thermochemistry.' He is regarded as one of the co-founders of physical chemistry along with the German physical chemist Friedrich Wilhelm Ostwald (1853-1932), the Dutch physical chemist Jacobus Henricus Van't Hoff (1852-1911) and the Swedish physical chemist Svante August Arrhenius (1859-1927). In 1894, Nernst became the first Professor of Physical Chemistry at the Gottingen University, Germany.

Nernst's early work was in electrochemistry, a field in which he made numerous contributions. Among his works in electrochemistry the theory of electrode potential and the solubility product (the product of the concentrations of the different types of ions in a saturated solution) were particularly important. He developed experimental methods for measuring dielectric constants, degree of ionic hydration, and pH (a measure of hydrogen ion concentration of a solution). It was Nernst who first suggested the use of buffer solution—mixed solutions of weak acids (or bases) and their salts, which resist changes in pH. He was the first to suggest the hydrogen electrode as an electrochemical standard.



Walther Hermann Nernst

Nernst's electrochemical work led him to thermodynamics. His most important work, the formulation of the third law of thermodynamics, was done during 1905-06. It was first known as 'Nernst heat theorem', which states that if a reaction occurs between pure crystalline solids then there is no change in entropy (energy unavailable to perform work and a measure of molecular disorder). This theorem, stated in a slightly different form came to be known as the

last law of thermodynamics, because the first law of thermodynamics had three discoverers (Julius Robert von Mayer, Rudolf Julius Emmanuel Clausius, and Hermann Ludwig Ferdinand von Helmholtz), the second two (Nicolas Leonard Sadi Carnot and Clausius), and the third, only one (Nernst). At the time the zeroth law of thermodynamics was not explicitly stated. This law, which is assumed by the other laws of thermodynamics, states that if two bodies are each in thermal equilibrium with a third body then all the three bodies are in thermal equilibrium with each other. It is not associated with any particular discoverer(s).

Nernst was a strong advocate of commercial application of scientific research and he himself was a prolific inventor. In 1897, he invented a form of electric lamp (later called Nernst lamp). He received a patent for the lamp on 8 July 1898. The Nernst lamp was an early form of incandescent lamp, but did not use a glowing tungsten filament. Instead, it used a ceramic rod that was heated to incandescence. A ceramic of zirconium oxide-yttrium oxide was used as the glowing rod. These lamps were about twice as efficient as carbon filament lamps used at that time and they emitted a more “natural” light (more similar in spectrum to daylight). One disadvantage of the Nernst lamp was that the ceramic rod did not conduct electricity at room temperature so the lamps needed a separate heater filament to heat the ceramic hot enough to begin conducting electricity on its own.

Nernst managed to make lot of money by selling the lamp. The patent for the lamp was sold for a million marks. However, it soon became obsolete with the invention of tungsten-filament lamp. In 1930, Nernst developed an electric piano replacing the sounding



Friedrich Wilhelm Ostwald

board with radio amplifiers. The piano used electromagnetic pickups to produce electronically modified and amplified sound in the same way as an electronic guitar. The piano could never be marketed successfully as musicians did not really appreciate it. He devised a solid-body radiator with a filament of rare-earth oxides, which came to be known as the Nernst glower. This proved to be useful in the field of infrared spectroscopy.

His work *Theoretische Chemie vom Standpunkte der Avogadro'schen Regel und der Thermodynamic* (1893; *Theoretical Chemistry from the Standpoint of Avogadro's Rule and Thermodynamics*) was regarded as one of the standard textbooks of the period

and it went through numerous editions and translations. Its main objective was to lay out the principles of a new approach to the study of chemistry.

Nernst was born on 25 June 1864 in Briesen in West Prussia (now Wabrzeno, Poland). He was the third child of Gustav Nernst and Otilie Nernst (*nee* Nerger). His father was a country judge. Nernst studied at the Royal Protestant Gymnasium at Graudenz (now Grudziadz), Poland, which

he joined in 1874. At the Gymnasium he developed an interest in poetry, literature and drama. For a brief time, he even considered becoming a poet.

Nernst began his studies of mathematics, chemistry and physics in April 1883 at the University of Zurich and later he studied at the Friedrich-Wilhelm University of Berlin and Karl-Franzen University at Graz. In 1887 he obtained his PhD degree from the Julius-Maximilian University of Wurzburg. His PhD supervisor was the German physicist Friedrich Wilhelm Georg Kohlrausch (1840-1910) and his thesis was entitled “On the electromotoric forces generated by the magnesium in metal plates carrying a heat current.” In 1887 he became assistant to

Wilhelm Ostwald at the Institute of Physical Chemistry at the Leipzig University.

In 1894 Nernst received three offers of appointment—Physics Chairs in Munich University and in Giessen University and the Physical Chemistry Chair in Gottingen University. He decided to take

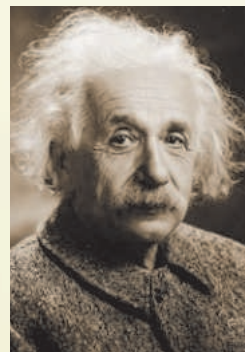


Friedrich Wilhelm Georg Kohlrausch

up the Physical Chemistry Chair in Gottingen University, where he established the Institute of Physical Chemistry and Electrochemistry and became its founder Director. In 1904 he succeeded Hans Landolt in the Chair of Physical Chemistry at Berlin University. In 1922 he resigned his post at Berlin University in order to

become the President of the Physikalisch Technische Reichsanstalt (Physical Technical Reichs Institute). However, after two years he came back to Berlin University, this time as Professor of Physics. In 1924 he became the Director of the newly established Institute of Physical Chemistry at Berlin University and remained in this position until his retirement in 1933.

Nernst played an important role in shaping the academic career of Albert Einstein. He was so highly impressed by Einstein's paper on the quantum mechanics



Albert Einstein

of specific heat at cryogenic temperatures that he went to Zurich to visit him in person. The year was 1909 and Einstein was then relatively unknown. Nernst's visit dramatically changed Einstein's status as a scientist. This is because many people thought “Einstein must be very clever fellow if the great Nernst comes all the way

from Berlin to Zurich to talk to him.” Nernst also offered him a Chair at Berlin University without teaching duties so that he could be free to pursue his research activities.

Nernst had persuaded Ernest Solvay (1838-1922), a Belgian industrial chemist to sponsor the great series of International Conferences (better known as Solvay Conferences) of physicists at Brussels starting in 1911, in which much of the new nuclear

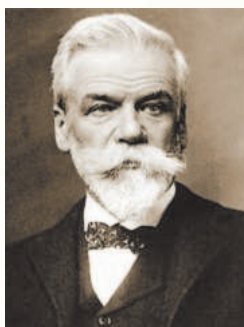


Jacobus Henricus Van't Hoff



Svante August Arrhenius

and quantum physics was discussed. Impressed by the success of the first conference, Solvay established the Solvay International Institutes of Physics and Chemistry at Brussels, which supported periodic conferences in which leading scientists considered a pressing topic. It also provided small grants to individual scientists. The Solvay Conferences on Physics provided an important forum for the development of quantum mechanics and its implications. The Solvay Conferences on Chemistry followed a similar format.



Ernest Solvay

Nernst was highly critical of Adolf Hitler and Nazism. His three daughters married men of Jewish origin. In 1933, the rise of Nazism in Germany under Hitler led to the end of Nernst's career as a scientist.

In addition to the Nobel Prize in Chemistry, Nernst received many other distinctions and awards for his significant contributions to science. He became a Foreign Member of the Royal Society of Chemistry, London in 1911 and was made a Foreign Member of the Royal Society of London in 1932. Nernst was the President of the German National Bureau of Physical Standards (1922-24). In 1912 the impressionist painter Max Liebermann painted Nernst's portrait.

Nernst died on 18 November 1941 at his home at Zibelle, Oberlausitz, near the German-Polish border.

Some important works on the life and work of Nernst are:

1. *The World of Walther Nernst: The Rise and Fall of German Science* by Kurt Mendelssohn, Macmillan, 1973.
2. *Walther Nernst and the Transition to Modern Physical Science* by Diana Kormos Barkan, Cambridge University Press, 1991.
3. *Walther Nernst: Pioneer of Physics and of Chemistry* by Hans-Georg Bartel and Rudolf P. Huebner, World Scientific, Singapore, 2007.

We would like to end this write-up by quoting Albert Einstein: "Nernst was not a one-sided scholar. His sound common sense engaged successfully in all fields of practical life, and every conversation with him brought something interesting to light. What distinguished him from almost all his fellow-

countrymen was his remarkable freedom from prejudices. He was neither a nationalist nor a militarist. He judged things and people almost exclusively by their direct success, not by social or ethical ideal. This was a consequence of his freedom from prejudices. At the same time he was interested in literature and such a sense of humour as is very seldom found with men who carry so heavy a load of work. He was an original personality; I have never met anyone who resembled him in any essential way."

References

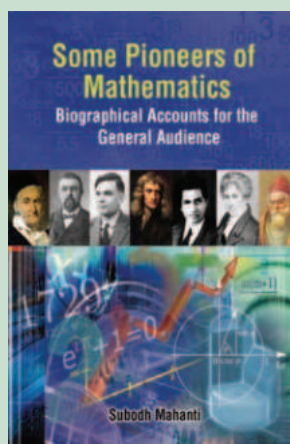
1. 100 Years with Nobel Laureates, New Delhi: Encyclopaedia Britannica (India) Pvt Ltd., 2001.
2. A Dictionary of Scientists, Oxford: Oxford University Press, 1999.
3. Chambers Biographical Dictionary (Centenary edition), New York: Chambers Harrap Publishers Ltd., 1997.
4. Einstein, Albert, "The Work and Personality of Walther Nernst", The Scientific Monthly, 54(2): 1995-1996, 1942.

5. The Cambridge Dictionary of Scientists (2nd edition), Cambridge: Cambridge University Press, 2003.
6. Oxford Dictionary of Science, Oxford: Oxford University Press, 1999.
7. Nye, Mary Jo., "Physical Chemistry" in J. L. Heilbron (ed.), The Oxford Companion to the History of Modern Science, Oxford: Oxford University Press, 2003.
8. Available sources on the Internet.

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

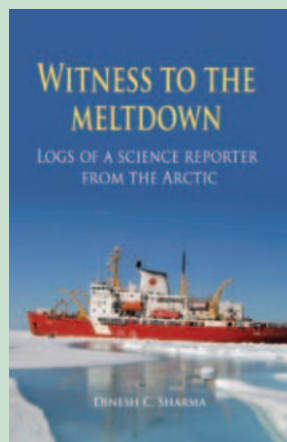
Dr. Subodh Mahanti worked in Vigyan Prasar (1994-2014) and co-ordinated several science popularisation projects. He has written extensively. He writes both in Hindi and English.

Recent Publications of Vigyan Prasar



Some Pioneers of Mathematics Biographical Accounts for the General Audience

Author: Subodh Mahanti
ISBN: 978-81-7480-264-4
Price: ₹200



Witness to the Meltdown Logs of A Science Reporter from the Arctic

Author: Dinesh C Sharma
ISBN: 978-81-7480-266-8
Price: ₹200



Story of the Sky

Author: Samar Bagchi
ISBN: 978-81-7480-272-9
Price: ₹50

Demystifying the Human Brain



Soumya Maitra

E-mail: soumya.maitra@gmail.com

The human brain has been the subject of curiosity, creativity and experimentation since time immemorial. Yet it is fascinating and downright baffling when you consider that the underlying genomic structure (and the physics) of the human brain have remained unchanged for the past 2,00,000 years. The same genetic code has been shaping the brain of the *Homo sapiens* for several thousand years, generation after generation. Yet it has evolved us from cave dwellers to the modern man of the 21st century. The same 23 pairs of chromosomes with the same four base pairs have moved us from being mere hunter-gatherers to conceive art around 30,000 years ago when we first painted on the walls of caves in France; that same chemistry in our brain has helped us create language, develop science around 5,000 years ago, and explore other aspects of human creativity that we take for granted today. And the pinnacle of its evolution lies in its ability to explore and comprehend itself today.

It is obvious then that an understanding of the genome and its chemistry alone cannot explain the remarkable journey of the human brain over the last 2,00,000 years. What is it that makes us write poetry and create works of art and fiction, solve complex mathematical problems, ponder existence of life beyond death, and much more? There is more to the stuff between our ears than meets the eye.

The modern approach to comprehending the mechanics behind the human brain is multidimensional in nature. Just as a blind man groping the elephant perceives different visions of the animal depending on where he touches, likewise our view of the brain (and human brain in particular) takes shape based on how we choose to model it. And over several centuries of human curiosity, our models have evolved from the unknown through the empirical (and often times abstract) to the more scientifically refined ones



Fig. 1: An artist's illustration of the brain's handedness, and its various dimensions in which it can be studied and understood. The right side of the brain is the dominant seat of creative thought, visual arts and music, appreciation of poetry, and many more. The left side of the brain is adept at logic and reasoning, understands mathematics and geometry, comprehends language and prefers order over chaos.

of the present day.

A comprehensive understanding of the human brain today calls for synergy amongst several related as well as divergent fields of science. At the very foundation of this understanding lies the genomics that makes us human. We might start at the very base, where the brain is no different from any other organ, whose function and structure is encoded in the genes of the organism, dictated by the adenine, thymine, guanine and cytosine molecules. An understanding of the genetic code that makes us human is essential in an understanding of the human brain. However, the genetic code alone



Fig. 2: The DNA in our 23 pairs of chromosomes has the machinery to build a complete human brain starting from an egg and a sperm cell. (Illustration by Lydia V. Kibiuk, Baltimore, MD)

cannot explain why we behave the way we do. It cannot explain the difference in character and behaviour between two identical twins. There are more than 7 billion people on the planet today, and each one of us is unique and different from the other in some way or the other; be it in the way we think, feel, behave or react to events through the passage of time in our lives. Surprisingly, however, the DNA sequences of any two individuals differ only by 0.1% on average, or about one in a thousand DNA base pairs.

Cellular anatomy marked the beginning of neuroscience in the 19th century. The works of such geniuses as Camillo Golgi and Ramon y Cajal laid the foundation of neuroscience in the 19th century. Their research and the work of other scientists revealed the workings of the brain. We now know

that the brain, the central nervous system and the peripheral nervous system all involve electrical signals and chemical interactions, every moment of our life. The brain and the nervous system are composed of nerve cells called neurons. These are special type of cells that are capable of conducting electric signals of magnitude ranging between -100 mV to +100 mV. The electrical signal (called an action potential) travels along the far end of cells called axons. The potential difference is maintained via diffusion process, based on Na⁺ and Ca⁺ ion concentration gradients between the inside and the outside of the neuron cell membrane. Each nerve cell has a cell body containing the nucleus, around which branch-like structures called dendrites protrude, which connect with the axons of other neurons through a minute gap known as a 'synapse', and receives electrical impulses as inputs. Chemicals called neurotransmitters are released from the axons and stimulate the flow of electrical signals in the next set of neurons thus maintaining the flow of the signal till it reaches

the target tissue (muscle) to cause movement. The cellular biology of the brain and the nervous system revolves around the study of the neuron, and inter-neuron communication using electrical impulses and neurotransmitter molecules, giving rise to our motion, actions, thoughts, behaviour, and consciousness.

The average human brain weighs around 1.4 to 1.5 kilograms, roughly 2% of the body weight. However, it requires 20% of the entire energy that we get from foods every day. And most of that energy goes into keeping the electrical and chemical balance in the brain in working order. Our very conscious existence is dependent on these electro-chemical processes going on constantly amongst billions of nerve cells throughout the day. On an average, each neuron connects with 10,000 other neurons to build up a massive parallel network of electrochemical pathways for processing information and generating response.

Once we have an understanding of the brain's cellular mechanism, the next natural progression for the curious mind is then to understand the anatomical (or structural) foundation of the brain. This is the science of cerebrum, cerebellum, and the medulla oblongata we studied as part of the central nervous system back in school. Physicians build a layer of abstraction on top of the molecular and cellular understanding, and rely on anatomical or structural view of the body and the brain for treating patients. However, anatomy, genes and cells alone cannot define our "humanness" or our intelligence. How about the functions of the brain relating to our emotions, thoughts, illusions, dreams, ability to learn and make decisions, consciousness, and our perception of space and time in which we exist? The brain seems to be highly organised with built-in circuitry specialised for different functions that we use on a daily basis. The modern study of the brain

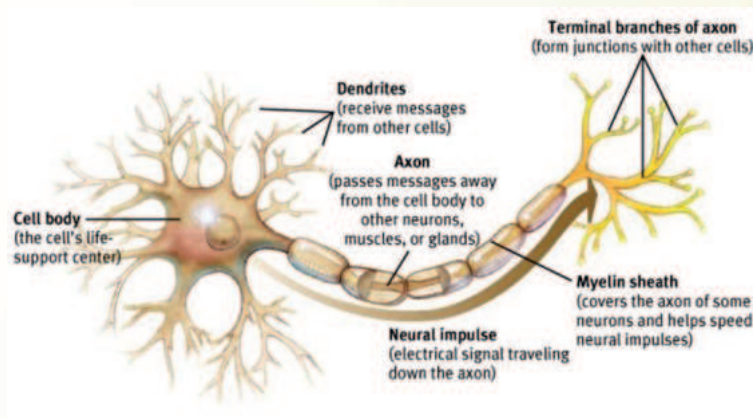


Fig. 3: Neurons are electrically excitable cells in the nervous system that process and transmit information. In vertebrate animals, neurons are the core components of the brain, spinal cord and peripheral nerves. (Source: Wikipedia)

involves sophisticated imaging techniques which are used to identify behavioural and functional areas of the brain. It is like mapping the brain. EEG, MRI/fMRI, PET and two-photon microscopy are some of the imaging tools and techniques used to map structure-to-function and also facilitate clinical diagnosis. With the help of these advanced imaging tools scientists have been able to map areas of the brain to functional characteristics (see Fig. 4).

Of all the dimensions in which the brain can be studied, perhaps the most pertinent view is the clinical one. The medical profession thrives on the knowledge of how the brain works. There are more than 600 known illnesses of the brain. Some of the common ones are depression, schizophrenia, autism, amnesia, Alzheimer's disease, and Parkinson's disease; but there are many more that we do not come across very often. And

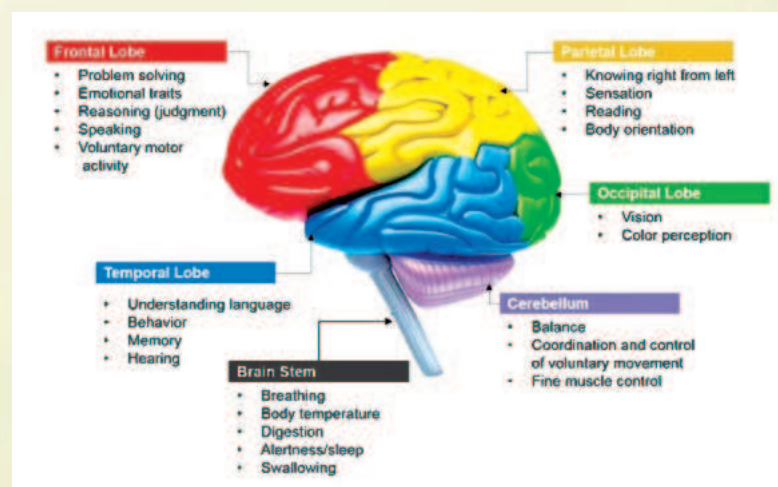


Fig. 4: A high-level map of structure-to-function in the human brain.

then there are injuries to the brain such as stroke and trauma. Understanding the structural and cellular basis, and having a functional map of the brain helps physicians in diagnosing the problems, isolating the region of the brain and prescribe drugs or surgical options to treat those ailments.

The human brain is made up of an estimated 86 billion nerve cells or neurons. Each of these neurons in turn makes a connection on average with seven to ten thousand other neurons. As we saw earlier, the language of the neurons is electrical and chemical in nature. Each neuron

has a cell body (which has the nucleus) which receives information or signals from other neurons via its many dendrites. Based on the nature of the cellular signals received, the neuron may decide to send or propagate an electrical signal of its own down its axon. This axon eventually terminates either on a dendrite of the next neuron in sequence, or at the neuromuscular junction of a muscle tissue in the body for movement. Our sense of self and everything that makes us who we are every moment of our lives is a result of this massive network of neurons talking to each other.

A phenomenon so complex, dynamic, and massively parallel in nature is not easy to study or understand. The simplest way to tackle this problem is through modelling and simulation. The model starts off as an empirical adventure, and evolves iteratively based on the understanding of the subject, until it becomes accurate enough to be used for predicting and testing new hypotheses on the subject. New fields of research such as Connectomics and Neuroeconomics provide the technical and theoretical framework for formulating models that can be applied both in the study of the brain, and also to understand how human decision making works to address practical

Continued on page 22

Himalayas with Special Reference to Indian Himalayas



Dr. M. A. Haque

Email: asrarulhaque@hotmail.com

Mountains cover about 24% of the world's land surface and accommodate about 12% of the human population. Another 14% live in immediate vicinity. Major rivers of the world originate in mountains and play vital role in supplying water to the downstream regions. Mountains play a vital role in water purification and water retention. Mountain ranges are also important for climate regulation and the impact can be seen much beyond the mountains. Mountains support essential ecosystem services and provide various resources. Mountains support a large variety of vegetation and associated organisms including about 28% of the world's forests.

Mountain ecosystems are rich in diversity and endemism and account for about half of the bio-diversity hotspots on Earth. Forests in the mountains provide effective protection against natural hazards like floods, avalanches, etc., by ensuring stability of the slopes. With increase in greenhouse gases (GHGs) in the atmosphere and consequent warming, mountains have attained even more importance because forests and wetlands at high altitudes play significant role in carbon sequestration. Another dimension is that with global warming it will be difficult for certain species to survive in their original habitats. Those organisms will be forced to find habitats which are not so warm. Thus species which could be otherwise exterminated may survive at higher altitudes, which are cooler.

There are fourteen mountains on Earth rising beyond 8,000 m. Interesting fact is that these mountains are still growing. Everest is growing at around 4mm/year, which is roughly the average for the other ten tallest mountains with one exception. Nanga Parbat is growing at a rate of about 7mm/year. According to the experts if the situation remains same, Nanga Parbat may become the tallest after about 1,81,250 years.

Himalayas

Himalayas is the mountain range separating the Indian subcontinent from the Tibetan Plateau. In common parlance it is the name given to the massive mountain system which includes the Karakoram, the Hindu Kush,



and various other ranges. That is why it is also called the Himalayan mountain system. The main Himalayan range is an arc which is about 2,400 km long extending from west to east starting from the Indus river valley to the Brahmaputra river valley. Width varies from about 400 km in the western part, i.e., Kashmir-Xinjiang region to about 150 km in the eastern part, i.e., Tibet-Arunachal Pradesh region. The complete range includes three coextensive sub-ranges. The northernmost sub-range known as the Great or Inner Himalayas is the highest. The Himalayas include Earth's highest points. Two peaks are more than 8,000 m high and more than hundred peaks are beyond 7,200 m high.

Origin of Himalayas

It is estimated that the Himalayas started to grow into a mountain range about 50 million years ago when the Indian Plate collided with the Eurasian Plate. Since that time, the Indian Plate has been continuing its northwards movement, initially at a rate

of about 16 cm/year which has currently slowed down to about 5 cm/year. The movement resulted in pushing slices of the Indian crust southward and the huge mass stacked up resulting in the formation of the Himalayan range. That is why several distinct sequences of rocks can be recognised in the Himalayas. The sequences are separated from one another and from the rocks of the Indian Plate by northward-dipping fault zones. A recent study suggests the age of the Himalayas to be more than 450 million years claiming that world's loftiest peaks may owe some of their heights to an earlier continental crash. The conclusion is that there was an older mountain range in place before the current Himalayas. But consensus is yet to come for this conclusion.

Geography of the Himalayas

Geographically, the Himalayas may be subdivided into five divisions from west to east. In their longitudinal structure (north to south), the Himalayas are divided by a series of parallel tectonic zones. The Sub- or Outer-Himalayas forms the foot-hill zone and these are delimited in the south by the large fans of Ganges alluvial deposits. The northern edge is a clearly outlined tectonic feature – the Main Boundary Fault. Between the Main Boundary Fault in the south and the Main Central Thrust in the north lies



the stretch of the Lesser Himalayas.

The Higher Himalayas consist of a single range. The average height exceeds 6,000 m and the width of this zone is about 24 km. There are certain subordinate ranges on the northern side of the Higher Himalayas. The same correspond to the Lesser Himalayas on the southern side. Examples of these ranges are the Zaskar, Kailash, and Nyanchentanglee. This zone is referred to as the Tibetan or Tethys Himalayas, which contains complete record of fossil-containing sediments starting from the Cambrian to the Tertiary period.

As far as the Indian Himalayas is concerned, the true divisions are based on the mountain ranges rather than the state boundaries. From west to east, the Indian Himalayas can be divided into Ladakh, Zaskar, Lahaul and Spiti, Chamba, Kinnaur, Kumaon, Garhwal, Sikkim and Arunachal. For convenience the Indian Himalayas can be divided just into three zones – the Shiwaliks or the Outer Ranges on the southern wing, the Middle Ranges like the Pir Panjal and the Dhauladhar. The central core of the Himalayas began to rise barely 35 million years ago, making them the youngest of the most awe-inspiring ranges in the world. The 5 million-year-old Shiwaliks are much younger. These peaks are still growing at the rate of about 5mm/year. The consequences are obvious in the form of earthquakes that rock the region separating the mountains from the plains.

Himalayan rivers

After flowing beyond Leh, in the state of Jammu and Kashmir, the Indus river is joined by its first tributary, the Zaskar, which helps green the Zaskar Valley. The Indus then flows past Batalik. When it enters the plains, its famous five tributaries – Jhelum, Chenab, Ravi, Beas, and Sutlej – join it. The mighty Ganges emerges from beneath the Gangotri glacier at a height of 3,959 m in the Garhwal region. There she is known as the Bhagirathi. Eighteen kilometres downstream, stands Gangotri, which was the source of the river until the glacier melted and retreated to its present position above Gaumukh. From here, onwards the river passes through the plains of India. Together the two, i.e., Indus and Ganges have formed the largest modern alluvial plains, the Indo-



Gangetic plain, which supports large chunk of Indian population.

Through the eastern part of India, flows the Brahmaputra, travelling from China to the plains of Assam. At the India-China border, the river drops down in height by several hundred metres. Finally, the meandering river meets the Ganges in Bangladesh and forms the most fertile and largest modern delta called the Ganges-Brahmaputra or the Great Bengal delta.

Climate

The Himalayas act as a great climatic divide for the region. Himalayan Range obstructs the passage of cold continental air into India in winter and also forces the south-westerly monsoon winds to give up most of the moisture travelling northward. The result is



heavy precipitation on the Indian side but arid conditions on the Tibet side. Hundreds of millions of people rely on water from the Himalayas' mighty glaciers. Important rivers fed by Himalayan glaciers are: Indus, Jhelum, Chenab, Ravi, Sutlej, Beas, Yamuna, Ganga, Kali, Karnali, Gandak, Kosi, Tista, Raikad, Manas, Subansiri, and Brahmaputra.

Recent concern is that the glaciers are shrinking due to rising global temperatures. A claim was made by the Intergovernmental Panel on Climate Change (IPCC) that all the ice and snow there could go by

2035. Later the claim was withdrawn. However, satellite observations and *in situ* measurements suggest that many of the more than 45,000 glaciers in the Himalayan and Tibetan regions are losing mass although observed rates of decline suggested that even small glaciers will not melt completely before the end of the current century. But the glaciers are being threatened by global warming, undoubtedly. One consequence of the glaciers melting faster will be that the lakes in the region may overflow resulting in floods in the valleys. To rectify the situation, the Third Pole Environment (TPE), an international programme led by the Chinese Academy of Sciences' Institute of Tibetan Plateau Research in Beijing has started certain initiatives. However, it is too early to conclude anything about the outcome.

We know that the region's population is expected to grow in future. India is expected to be the most populous country in the world by mid-21st century. Obviously, the requirement of water in the country will grow and stress on water sources will also grow. That is why glaciers in the Himalayas acquire much more importance. They serve as vital source of water for large chunk of population in the country. No doubt the IPCC claim in the 2007 Report that Himalayan glaciers could disappear by 2035 turned out to be an error (*Nature* **463**, 276-277; 2010), it is obvious that broader concern about the rapid loss of Himalayan glacier ice was not incorrect. But it is not clear how fast it may happen and how the same will affect water resources. There is no glacier inventory for the entire region. The satellite studies offer a rough estimate of glaciated areas. Remoteness, high altitudes and harsh weather conditions hamper measurement from the ground.

Earthquakes in Himalayas

The Indian Himalayas have experienced some significantly strong earthquakes in the past 100 years. The famous earthquake that hit Nepal in AD 1933 killed thousands of people in Nepal and northern India. Among the others were: Kinnaur Earthquake-1975, Dharchula Earthquake-1980, Uttarkashi Earthquake-1991, Chamoli Earthquake-1999, Kashmir Earthquake-2011, and Nepal Earthquake-2015. Historical records show that at least as far back as the early

1800s, sizeable quakes have erupted in the region every few decades. But since 1950, the Himalayas have remained reasonably quiet except a few quakes as mentioned above. Indeed, Researchers report that some areas may not have experienced major earthquakes in the past 500 years.

The main driving engine in the system that causes earthquakes is the movement of the Indian Plate, which winds up the Greater Himalaya like a giant spring compressed against the Himalayan plateau. Deep beneath Tibet, India slides northward with relative ease. Experts are of the opinion that sooner or later the lock holding the spring will break, propelling the Himalaya southward, resulting in giant earthquakes. Satellite-based measurements reveal that India and southern Tibet are colliding and converging at a rate of about two metres a century, and that a relatively small swathe of the Tibetan Plateau's southern edge is absorbing most of the convergence. Experts are of the view that massive earthquakes may offer the only way for release of the mounting strain. Certain experts have opined that up to seven earthquakes in the 8.1 to 8.3 magnitude range are overdue in the region. Obviously, this is a cause of serious concern for India.

Seasonal cycle of earthquakes

Data obtained from seismograms have indicated that earthquakes in the Himalayas followed a seasonal cycle, twice the numbers of earthquakes occurred during the winter (from December to February) than in summer. But there were no clues for the seasonal variation. Now, using GPS (Global Positioning System) and GRACE (Gravity Recovery And Climate Experiment) data, scientists have provided an explanation for the same. The Ganga Basin acts like a giant trampoline, sagging in summer under the force of the monsoons. The annual rains swell the Ganga River, erode the hillsides and mountains. The river receives sediment and carries it to the Ganga River Basin in the south of the Himalayas. The water and sediment weigh heavily on the Basin. Once the monsoon is over, the water leaves the basin and the basin rises. Thus during the dry winters it rebounds. This rebounding gives earthquakes a little "kick". Climate change may bring changes



in the rain pattern and also in the number of rainy days in monsoon. That change may make prediction of earthquakes even more difficult.

Landslides and soil loss in Himalayas

Soil cover in the Himalayas is not uniform. Different types of soil are found in different areas. There is natural erosion of soil in the Himalayas leading to continued loss of fertile soil, particularly during monsoon periods. Human interference is also responsible for keeping the Himalayas unstable. For example, slate has been used since ages for roofing. In recent times craze for slates from Dhauladhar range in Himachal Pradesh has increased. Dhauladhar ranges face extreme weather conditions. Snow and rain in the region act as active agents of erosion. Mining is going on there for more than hundred years. British government had stopped mining in the area on account of mass



protest. But in the post-Independence era mining was resumed.

Removal of top soil, dumping of waste and removal of trees are the main factors supporting erosion leading to land mass becoming barren. Blasting for mining or road construction, etc. adds to the

problem. Blasting is directly responsible for landslides and rockslides. Also, vegetation does not grow easily in the blast affected areas. The Himalayan region is as such dynamic and blasting tremors add to the dynamic processes. Net result is that the rivers of the Himalayas carry about 2 billion tonnes of sediments and soil every year on account of erosion. This factor is important as 78% of the land surface in the world's mountain areas has been classified by the FAO as not suitable or only marginally suitable for agriculture.

The Indian Himalayan Region (IHR) is not an exception. Still, vast majority of mountain population in IHR is engaged in agricultural activities. Mixed farming of intensive nature is quite common at lower altitudes. Soil is shallow and poor and the land sloping. Productivity in the area remains low and the harvest cannot compete in price with products from outside the mountains. At higher altitudes even marginal farming is difficult. Pastoralism is the only way to earn livelihood. Environment aberrations and growth in population are affecting even pastoral way of life.

Global warming and IHR

Global warming and climate change are expected to worsen the situation. It is known that the mountain regions world over have experienced above-average rise in temperature in the 20th Century. For example, in the Himalayas, the rise in temperature at higher altitudes has been three times greater as compared to the world average. Predictions are that the temperatures will rise in mountain areas more than the global average during the 21st century as well. The rise may be two to three times the rise recorded during the 20th Century. It is already reported that apple production in Himachal Pradesh decreased between 1982 and 2005 as the increase in maximum temperature in the region led to reduction in total chilling hours. With further increase in temperature there may be all-round decrease in apple production in the Himalayan region. Also, there is possibility that the line of production may shift to higher altitudes. Other crops may also suffer. Even if in other mountain areas the consequences

Continued on page 25

Numbers that Hold Hands



Dr. C.K. Ghosh

E-mail: ckghosh@ignou.ac.in

We, human beings, are always keen to hold hands so that we move together for achieving common goals, so that we stay together through our joys and sorrows. Have we ever wondered if numbers also hold hands? For example, whenever there is a dispute in family life, or at workplace we try to seek amicable solutions. Similarly, there are numbers which behave amicably and are called 'Amicable numbers' or 'Amicable pairs'. Amicable numbers are two different numbers so related that the sum of the proper divisors of each is equal to the other number.

To understand the significance of such pairs, we need to know what is meant by 'Proper divisors'. These are the divisors of a number, other than itself. For example, for 8, the proper divisors are 1, 2 and 4; for 9, these are 1 and 3.

Now, let us study the numbers 220 and 284. The proper divisors of 220 are 1,2,4,5,10,11,20,22,44,55 and 110 and we see that $1+2+4+5+10+11+20+22+44+55+110=284$; and that the proper divisions of 284 are 1, 2, 4, 71, and 142 of which the sum, $1+2+4+71+142 = 220$. Hence 220 and 284 form a pair of amicable numbers. As a matter of fact, (220, 284) happens to be the smallest such pair.

The current year, 2016, marks the 150th anniversary of the discovery of the second smallest pair (1184, 1210) in 1866. It is credited to a then teenager, B. Nicolò Paganini (not to be confused with the composer and violinist by the same name). This pair was overlooked by the earlier mathematicians.

Amicable numbers date back to the Pythagoreans. The Iraqi mathematician, Thabit Ibn Qurra (826-901) derived a general formula by which some of these numbers can be identified. Several other Arab mathematicians had studied amicable numbers, some of whom are al-Majriti (died 1007), al-Baghdadi (980-1037), and al-Farisi (1260-1320). The pair (9363584, 9437056) was discovered in the 16th Century by the Iranian mathematician, Mohammad Baqir Yazdi. As per some popular belief, Rene

Descartes is known to have discovered the above pair.

Qurra's formula was rediscovered by Pierre de Fermat (1601-1665) and Rene Descartes (1596-1650) to whom it is at times attributed. Leonhard Euler (1707-1783) also discovered dozens of new pairs.

By 1946, 390 pairs of amicable numbers were known. With the advent of computers, many thousands were subsequently discovered.



Pierre de Fermat



Rene Descartes



Leonhard Euler

Mathematicians have been targeting such pairs up to a certain upper limit, which was set at 10^8 in 1970. It got extended to 10^{10} in 1986, 10^{11} in 1993, and to 10^{17} in 2015. As of December 2015 the number of amicable pairs is 40,871,144.

The approach taken by Qurra to discover the amicable pairs is as under:

If,

$$a = 3 \times 2^{i-1} - 1$$

$$b = 3 \times 2^i - 1$$

$$c = 9 \times 2^{2i-1} - 1,$$

where $i (>1)$ is an integer; a, b, c are prime numbers,

then $(2^i \times a \times b)$ and $(2^i \times c)$ are a pair of amicable numbers.

For example, for $i=2$

$$a = 3 \times 2^1 - 1 = 3 \times 2 - 1 = 6 - 1 = 5$$

$$b = 3 \times 2^2 - 1 = 3 \times 4 - 1 = 12 - 1 = 11$$

$$c = 9 \times 2^{2 \cdot 2 - 1} - 1$$

$$= 9 \times 2^{4-1} - 1 = 9 \times 2^3 - 1$$

$$= 9 \times 8 - 1 = 72 - 1 = 71$$

So, a, b, c are all primes.

$$2^i \times a \times b = 2^2 \times 5 \times 11$$

$$= 4 \times 5 \times 11 = 220,$$

$$\text{And } 2^i \times c = 2^2 \times 71 = 4 \times 71 = 284$$

So, $i = 2$ generates the pair (220, 284).

Similarly, it can be verified by the reader that, $i=4$ generates the pair (17296,

18416), and $i=7$ generates (9363584, 9437056).

Numbers of the form $3 \times 2^i - 1$ are known as 'Thabit numbers'. From the expression of ' a ' and ' b ' it can be seen that these are consecutive Thabit numbers. So one of the basic conditions for generation of an amicable pair is that two consecutive Thabit numbers should be prime. This imposes a serious restriction on the possible values of ' i '.

We conclude the discussion on amicable numbers by stating the first ten amicable pairs: (220, 284); (1184, 1210); (2620, 2924); (5020, 5564); (6232,

6368); (10744, 10856); (12285, 14595); (17296, 18416); (63020, 76084); and (66928, 66992).

Another class of pairs, the components of which hold hands are called 'Friendly numbers'. To learn about friendly numbers, we need to understand the meaning of 'abundancy'. It is the ratio between the sum of divisors of a number and the number itself. For example, let us take the numbers 6 and 28.

The divisors of 6 are 1,2,3,6. So, the abundancy = $(1+2+3+6)/6 = 12/6 = 2$

The divisors of 28 are, 1,2,4,7,14,28. So the abundancy = $(1+2+4+7+14+28)/28 = 56/28 = 2$

So, 6 and 28 are friendly numbers or friendly pairs. Here the shared value '2' is an integer. It may not be the case with all numbers, which we shall see later. Interestingly, 6 and 28 belong to a class of numbers, called 'perfect numbers'. Each of these numbers is exactly equal to the sum of its divisors, except itself (also known as *aliquot sum*).

For example,

$$6 = 1+2+3$$

$$28 = 1+2+4+7+14$$

The first five perfect numbers are 6, 28, 496, 8128 and 33550336. So quite



obviously, the abundancy of each such number is '2'.

As in the above case, if the abundancy is shared between more than two numbers and if the number of such numbers among which it gets shared is 'n', then these are called 'friendly-n-tuplets'. The perfect numbers fall in this category.

Let us now take the example of 30 and 140.

The 'abundancies' are as under:

For 30

$$A(30) = (1+2+3+5+6+10+15+30)/30 = 72/30 = 12/5$$

For 140

$$A(140) = (1+2+4+5+7+10+14+20+28+35+70+140)/140 = 336/140 = 12/5$$

So, we can call 30 and 140 a friendly pair. But they are actually a member of 'friendly-5-tuplets', because the abundancy of each of 2480, 6200, 40640 is also 12/5, which the reader may verify.

The numbers which do not have any such friends are called 'solitary numbers'. As a matter of fact, most of the numbers are solitary, as can be seen for such numbers for which the sum of the divisors is a co-prime of the number itself. Let us take the example of '21'.

The sum of the divisors = 1+3+7+21 = 32, which is prime to 21. In other words, their Highest Common Factor is '1'. The abundancy is 32/21 which is an irreducible fraction. So '21' is a solitary number.

Same is the situation with every prime number 'p'. The sum of the divisors would be (p+1) which is essentially prime to 'p'. So, all prime numbers are solitary numbers.

No general method exists for determining which number is friendly and which is solitary. The classification is done by way of trial and error method. Incidentally, the smallest number where classification is not known as of 2009 is '10'.

As a conjecture '10' is taken to be solitary. However, if it turns out not to be so, then its friend would be quite a large number.

Dr. C.K. Ghosh is Regional Director, IGNOU Regional Centre Delhi-3, who takes keen interest in mathematics.

Himalayas with Special Reference to Indian Himalayas... (continued from page 27)

may not be very serious on account of better preparedness and improved infrastructure, in the IHR the consequences will be serious due to prevalent poverty, weak infrastructure, lack of preparedness, etc.

Conclusion

The IHR has been a harbinger of environmental conservation. Famous Chipko Movement took place in the Garhwal region in 1974. Similarly, a number of traditional institutions like Dzumsa, Mangma, and Dwichi are there in the IHR. Another important event which has not been widely publicised is that even during the British period the western Himalayan region had shown the path of community-forestry in the form of "Van Panchayats". The movement forced the British to desist from its centralising tendencies. Experts say that the concept of *Van Panchayats* is far more legally sustainable, as it had its origin in the Indian Forest Act. Much later, the concept of JFM (Joint Forest Management) was introduced in the 1990s. Also, it is rarely publicised that while doing normal agriculture, the mountain people practise sustainable land management and perform biodiversity conservation. The agricultural practices followed by the farmers in the IHR



also take care of soil conservation through healthy management of water and watershed and provide protection against natural hazards like floods, landslides, avalanches, etc. They also contribute towards carbon sequestration and climate mitigation. In addition they preserve cultural and natural landscapes which are quite important for recreation and tourism activities.

As explained above the mountains may prove possible safe refuge for the biodiversity which will get threatened outside the mountains on account of climate change. Degradation of IHR may result in reduced chances of survival of such organisms. Also, water availability for large part of the country will get affected. There may be more floods and droughts outside the IHR

due to degradation in the IHR. Availability of various resources like fruits, nuts, medicinal plants, vegetables, timber, fuelwood, honey, etc., will also be adversely affected. In addition, tourism will be affected leading to economic and financial loss for the region and for the entire country.

The IHR has to be considered a highly sensitive area and it needs to be managed in a special way compared to the other parts of the country. Regular monitoring of the area is essential and all activities

which may result in degradation of the area have to be stopped or strictly regulated. For example, mining, tree felling, road and rail construction, urbanisation, adoption of modern agricultural practices have to be highly regulated and with adequate safety measures. Otherwise the area may suffer and serious consequences will be seen even outside the IHR.

Dr. M.A. Haque is a PhD from JNU, New Delhi and has held important positions in the Central Pollution Control Board, and the Ministry of Environment & Forests. He is visiting faculty to several Universities, Management Institutes, and Professional Institutes. During 2007-2008, he was UNDP Adviser in Afghanistan

Male infertility — Tests and Treatments



Dr. Yatish Agarwal
E-mail: dryatish@yahoo.com

Strange as it may seem, many men who enjoy being Casanovas with a high-spirited sexual drive and face no difficulty in sexual function, may still be affected with infertility. The crux of the matter is: a low sperm count (oligospermia), or, more severely, the absence of sperm (azoospermia) in the male ejaculate can exist without any tell-tale signs. The hitch may come to fore only when a couple tries to make a baby and fails, and undergoes tests for infertility.

Signs and symptoms

Since male infertility may not have any obvious signs or symptoms, a great majority of men who are infertile are oblivious of their condition. When asked to undergo fertility tests by a doctor, they often equate their sexual ability with fertility, and, hence, avoid taking the semen test. Instead, they tend to push their wives through a complete battery of tests, while refraining from undergoing the most simple of tests themselves. This prolongs the agony of the childless couple quite unnecessarily.

Some men affected with infertility may, however, demonstrate definite signs and symptoms. Some may complain of pain, swelling or a lump in the testicle area, while others may consult the doctor for decreased facial or body hair or other signs related to chromosome or hormone abnormality, a low sex drive, or difficulty in maintaining an erection (erectile dysfunction). In a number of cases, the problem may stem due to a common condition called varicocele, wherein the testicular veins become dilated and tortuous, or a condition that blocks the passage of sperm may cause signs and symptoms.

When to see a doctor

A couple should see a doctor if they are unable to conceive a child after a year of regular, unprotected sexual intercourse. In that case, both partners need to undergo a thorough evaluation.

Sometimes the signs and symptoms point towards a possible male problem. If a male has pain, discomfort, a lump or swelling in the testicular area, has a history of testicle, prostate or sexual problems, has erection or ejaculation problems, low sex drive or other problems with sexual function, he might need to see a doctor. Some medications also can impair sperm production and decrease male fertility.

A number of risk factors may possibly be linked to low sperm count. They include:

- Smoking tobacco
- Drinking alcohol
- Use of certain illegal drugs, such as marijuana, cocaine or anabolic steroids
- Exposure to toxins such as chemicals, pesticides, radiation or lead, especially on a regular basis
- Performing prolonged activities such as bicycling or horseback riding, especially on a hard seat or poorly adjusted bicycle
- Testicles being exposed to too much heat

- Having certain past or present infections
- Being overweight
- Being born with a fertility disorder or having a blood relative with a fertility disorder
- Having had a prior vasectomy or vasectomy reversal
- Having certain medical conditions, including tumors and chronic illnesses
- Undergoing cancer treatments, such as surgery or radiation
- Taking certain medications

Seeing a specialist doctor

Faced with the difficulty of childlessness, you may begin by seeing your family doctor. However, s/he may well refer you to an infertility specialist. Some urologists and gynaecologists are specially trained to manage and treat medical issues related with infertility.

The doctor would take a detailed clinical history, and may ask you and your partner specific questions which might help him/her identify the underlying cause behind childlessness. Your doctor may also ask about your sexual habits. Once s/he has taken the medical history, s/he would carry out a general physical examination. This includes the examination of the genitals and questions about any inherited conditions, chronic health problems, illnesses, injuries or surgeries that could affect fertility.

Medical tests

The doctor would ask you and your partner to undergo some medical tests. These tests might help identify an underlying health problem or a specific cause of infertility.

For men, the following tests may prove useful:

Semen analysis

A semen analysis test is the most basic test carried out to evaluate male fertility. The seminal ejaculate specimen is examined in the laboratory under a microscope. Sperm count is determined by counting the average number of sperm present within squares on a grid pattern. Else, a computer is used to measure the sperm count.



To collect a semen sample, the doctor will advise the candidate to masturbate and ejaculate into a special container. It is also possible to collect sperm for examination during intercourse, using a special condom.

A common cause of low sperm count is incomplete or improper collection of a sperm sample. Most doctors will check two or more semen samples over time to ensure consistency between samples. To ensure accuracy in a collection, the following precautions must be taken:

- The candidate must abstain from ejaculating for at least two but no longer than seven days before collecting a sample
- The candidate must ensure that the complete seminal ejaculate is collected into the collection cup
- The candidate must avoid the use of lubricants because these products can affect sperm motility
- If a candidate has had a major illness or suffered a severely stressful event, he must wait at least three months for the recovery before undergoing the test

Semen analysis results

Normal sperm densities range from 15 million to greater than 200 million sperm per millilitre of semen. A male is considered to have a low sperm count if he has fewer than 15 million sperm per millilitre or a total of less than 39 million sperm per ejaculate.

There are many factors involved in reproduction, and the number of sperm in the semen is just one. Besides the sperm counts, sperm motility, and the percentage of sperm with normal morphology also play a considerable role in male fertility. The level of fructose in the semen may also be significant.

Caveat

Lower than normal sperm counts can result from testing a sperm sample that was taken too soon after the last ejaculation; was taken too soon after an illness or stressful event; or didn't contain all of the semen ejaculated because some was spilled during collection.

Ultrasound

Depending on the initial findings, the doctor may ask for further tests to look for the cause of a low sperm count. This can include an ultrasound test of the scrotum, prostate and surrounding tissues. Ultrasound uses high-frequency sound waves to look at the internal structures.

With a *scrotal ultrasound*, the testicles, epididymis, testicular veins and supporting structures can be examined.

A *transrectal ultrasound*, on the other hand, can check the prostate, and for blockages of the tubes that carry semen, the ejaculatory ducts and seminal vesicles. The technique employs a small lubricated wand. This is inserted into the rectum to examine these organs from close quarters.

Hormone testing

Hormones produced by the pituitary, hypothalamus and testicles play a key role in sexual development and sperm production. Blood tests can help determine the levels of these hormones, and can point to a diagnosis.

Post-ejaculation urinalysis

Sperm in the urine can indicate that sperm are traveling backward into the bladder instead of out through the penis during ejaculation. This condition is called retrograde ejaculation.

Genetic tests

When sperm concentration is extremely low, genetic causes could be involved. A blood test can reveal whether there are subtle changes in the Y chromosome — signs of a genetic abnormality. Genetic testing

may also be ordered to diagnose various congenital or inherited syndromes.

Testicular biopsy

This test involves removing samples from the testicle. It may be used if a semen analysis shows no sperm at all. The results of the testicular biopsy will tell if sperm production is normal. If it is, the problem may be caused by a blockage or another problem with sperm transport.

Anti-sperm antibody tests

These tests are used to check for immune cells (antibodies) that attack sperm and affect their ability to function.

Specialised sperm function tests

A number of tests can be used to evaluate how well sperm survive after ejaculation, how well they can penetrate an egg and whether there is any problem attaching to the egg.

Self measures

Some simple steps taken at home may increase a couple's chances of finding success in conception.

Knowing when fertilisation is possible

A woman is likely to become pregnant during ovulation — when her ovary releases egg. This occurs around the middle of the menstrual cycle (between periods). Experts generally recommend having intercourse every two days near the time of ovulation. This will ensure that sperm, which can live several days, are present when conception is possible.

Frequency of sex

Having sexual intercourse every other day around the time of ovulation increases the chances of pregnancy.

Avoid the use of lubricants

Some products such as K-Y jelly, lotions, and saliva have been shown to reduce sperm movement. Avoid using such lubricants.

Nutritional supplements

Evidence is still limited on whether — or how much — herbs or supplements might help increase sperm count or overall sperm health. Although there is no conclusive information on the benefit of dietary supplementation, certain vitamins, minerals and amino-acids may improve sperm count or sperm quality. They include alpha-lipoic acid, anthocyanins, L-arginine, astaxanthin, beta-carotene, biotin, L-acetyl carnitine, L-carnitine, cobalamin, co-enzyme Q10, ethyl cysteine, folic acid, glutathione, inositol, lycopene, magnesium, n-acetyl cysteine, pentoxifylline, polyunsaturated fatty acids, selenium, vitamins A, C, D and E, and zinc.

Some don'ts

Avoidance of some known factors that can affect sperm count and quality might help improve fertility:

- Don't smoke.
- Limit or abstain from alcohol.
- Steer clear of illegal drugs.



- Talk to your doctor about medications that can affect sperm count.
- Keep the weight off.
- Reduce stress.

Treatments

Depending upon the root cause, a man with a low sperm count may benefit with several kinds of treatment. These include the following:

Surgery

Surgery may be useful if a person has varicocele, a condition marked by swelling of the veins that drain the testicle. Surgery can also repair and fix an obstructed vas deferens tube (which carries sperm to the ejaculatory duct).

Treating infections

Antibiotics can cure an infection of the reproductive tract, but this doesn't always restore fertility.

Hormone treatments and medications

Hormone replacement or medications may be prescribed to change hormone levels. It can take between three and six months before positive effects begin to show.

Assisted reproductive technology (ART)

ART treatments involve obtaining sperm through normal ejaculation, surgical extraction or from donor individuals, depending on the specifics of a case and wishes of the couple. The sperm is then inserted into the female genital tract, or used for *in vitro* fertilisation or intracytoplasmic sperm injection.

When treatment doesn't work

Sometimes male fertility problems cannot be treated, and it is impossible for a man to father a child. If this is the case, a couple can consider either using sperm from a donor or adopting a child.

Prof Yatish Agarwal is a physician and teacher at New Delhi's Safdarjung Hospital. He has authored 47 popular health-books.

Demystifying the Human Brain... (continued from page 30)

real-world phenomenon. (Connectomics is the production and study of comprehensive maps of connections within an organism's nervous system, typically its brain or eye. Neuroeconomics is an interdisciplinary field that seeks to explain human decision making, the ability to process multiple alternatives and to follow a course of action.) These models can be implemented in virtual simulators on a computer to build our understanding of the inner workings of the brain, and explain how we evaluate multiple alternatives for a given scenario, and how we follow a defined course of action. The new field of Connectomics for instance, involves slicing a brain into fine-grained pieces and then using a new MRI technique called Diffusion Spectrum Imaging to analyse how water molecules move along nerve fibres. The result is a colour-coded visualisation of the brain's major neural pathways mapping structure to function.

A complete understanding of the human brain requires the application of several disparate disciplines. And the faculty of metaphysics is probably the oldest dimension of study where philosophers have pondered the origin and the workings of consciousness and free will. The mind-body dichotomy wherein the mind has been perceived as an external entity outside of the brain has been the source of contention for

ages. With recent advances in technology, neuroscience is beginning to address such questions which were hitherto the domain of the abstraction and philosophy.

We live in exciting times. More than ever before, our lives and our world are shaped by the technology that we have innovated. A few years ago both the United States and the European Union set in motion two independent research initiatives on mapping the human brain. The Blue Brain Project, run by the Brain and Mind Institute of the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland since 2005, aims at reconstructing a synthetic brain by reverse engineering how a biological brain works. In 2013, the BRAIN (Brain Research through Advancing Innovative Neurotechnology) project was launched in the US. The goal of the BRAIN project is to use advanced imaging technology to map the complete human brain and arrive at a comprehensive understanding of brain functions. By far the two projects are the most ambitious scientific endeavours undertaken, that requires collaboration amongst mathematicians, computer scientists, biologists, chemists, philosophers, and many other disciplines.

Of course, such colossal undertakings are fraught with ethical and societal implications as well. Sci-fi movies of recent

times such as 'Total Recall', 'Transcendence', and 'Transfer' all dabble in the social and ethical implications of use of technology in augmenting the human brain. If and when we do map the entire human brain, decode all its secrets, and perhaps also become able to reconstruct a synthetic brain (or maybe artificial intelligence), will we have the right to manipulate the brain and control the mind of another human being? While it might be okay to use the knowledge and the technology for clinical purposes in curing illnesses such as autism, schizophrenia, amnesia, Alzheimer's, etc., can it also be misused to alter one's perception, memory, consciousness, and the very state of existence? This exciting new field of research and experimentation raises far more questions (both scientific and ethical) than it intends to answer. If we do not tread cautiously in this exciting field of research, it might very well change the age-old Cartesian philosophy to say "I think, therefore you exist", literally!

Soumya Maitra is a popular science writer with interest in basic science and computer applications. He is an alumnus of Birla Institute of Technology, Mesra, and an IT Project Manager at Syntel Canada in Toronto. Outside work, he is a hobbyist photographer and a member of the Toronto Camera Club.

Recent Developments in Science and Technology



Biman Basu

E-mail: bimanbasu@gmail.com

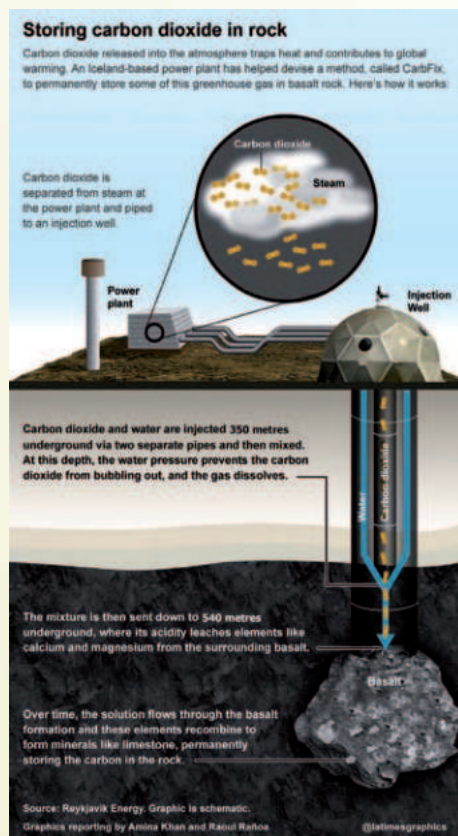
Waste carbon dioxide turned into stone

When fossil fuels like coal or gas are burned, the carbon stored within them is released into the air in the form of carbon dioxide, which is a greenhouse gas. Carbon dioxide traps heat in the atmosphere, leading to a steady rise in global temperatures that threatens polar ice reserves and contributes to rising sea levels. It also disturbs weather cycles leading to more frequent occurrence of extreme weather phenomena, causing widespread damage to life and property across the globe.

The only way to tackle the menace of increasing levels of carbon dioxide in the atmosphere is by reducing fossil fuel consumption and 'carbon capture and storage' (CCS). The 2014 report of the Intergovernmental Panel on Climate Change suggests that without a viable CCS technology, it may not be possible to limit global warming adequately. But till recently, CCS projects tried out in some countries made little progress. It has been tried at only a handful of sites, and most experiments have involved pumping pure carbon dioxide into sandstone, or deep, empty mines with the objective of trapping the carbon dioxide under rocks. But there was also a danger that any miscalculation could result in emissions making their way back up through fractures, or that natural earthquakes or tremors caused by the injection itself could rupture subterranean reservoirs and allow its contents to escape.

Now, scientists and engineers working at a major power plant in Iceland have shown for the first time that carbon dioxide emissions can be pumped into the earth and changed chemically to a solid within months, instead of decades as believed earlier, demonstrating a radical new way to tackle climate change (*Science*, 9 June 2016 | doi: 10.1126/science.aad8132). The Hellisheidi power plant is the world's largest geothermal facility; it and a companion plant provide the energy for Iceland's capital, Reykjavik. Although the plant runs on geothermal steam, the process is not completely clean; it also brings up volcanic gases, including

carbon dioxide and nasty-smelling hydrogen sulphide. The plant produces 40,000 tonnes of CO₂ a year. Although it is only about 5 percent of the emissions of an equivalent coal-fired plant, it is still considerable.



When carbon dioxide and water are together pumped into basaltic rock it turns into carbonate minerals over time thereby sequestering carbon.

Lab experiments had earlier shown that, unlike the sedimentary rocks that most other CCS projects have used for injection, basaltic rocks contains plenty of calcium, iron and magnesium, which can precipitate out carbon. Experiments showed that large amounts of water would also have to be pumped in along with carbon dioxide to make the reaction go.

In 2012, under a pilot project called 'Carbfix', researchers at the Hellisheidi plant began mixing the emitted gases with the water pumped from below and reinjecting the solution into the volcanic basalt below. It

has been known that in nature, when basalt is exposed to carbon dioxide and water, a series of natural chemical reactions takes place, and the carbon precipitates out into a whitish, chalky mineral. But no one knew how fast this might happen. Previous studies had estimated that in most rocks, it would take hundreds or even thousands of years. But to the utter surprise of the researchers, in the basalt below Hellisheidi, 95 percent of the injected carbon was solidified in less than two years. According to lead author Juerg Matter from Southampton University, UK, "Of our 220 tonnes of injected CO₂, 95% was converted to limestone in less than two years".

Harmless bacteria block mosquitoes from transmitting Zika

In recent months the mosquito-borne Zika virus has created a scare in many countries. Zika has now affected 39 countries and territories in the Americas and according to one estimate, at least four million people will be infected by the end of the year. The virus is spread mostly by the bite of an infected *Aedes* species mosquito (*Ae. aegypti* and *Ae. albopictus*). These mosquitoes are aggressive daytime biters. Although in healthy humans Zika virus causes only mild symptoms, known as Zika fever, which often is accompanied by skin rash, headache, and pain in the muscles, Zika can be passed from a pregnant woman to her foetus and infection during pregnancy can cause certain birth defects such as microcephaly (an abnormally small head and underdeveloped brain) in the new-born. Scientists believe the virus has also contributed to rising cases of a neurological disorder called Guillain-Barre syndrome (a condition characterised by pain and weakness and sometimes paralysis of the limbs).

As yet no approved Zika virus vaccines or antiviral medications are available. Till now the only way to prevent Zika infection was through mosquito control, but ongoing mosquito control strategies have not been adequate to contain the spread of the virus. Now, researchers have



Aedes aegypti loses its capability to transmit Zika virus when infected with the harmless bacterium *Wolbachia pipientis*.

come up with an entirely different route to prevent transmission of the Zika virus – by infecting *Aedes aegypti* mosquitoes with a harmless bacterium called *Wolbachia pipientis* commonly found in bees and butterflies. Researchers at the University of Wisconsin-Madison in USA have confirmed that the bacterium can completely block transmission of Zika in *Aedes aegypti* – the species of mosquito responsible for passing the virus onto humans (*Scientific Reports*, 1 July 2016 | DOI: 10.1038/srep28792). Matthew Aliota, a scientist at the UW-Madison School of Veterinary Medicine (SVM) and first author of the paper says the bacteria could present a “novel biological control mechanism,” aiding efforts to stop the spread of Zika virus.

According to the researchers, an important feature of *Wolbachia* is that it is self-sustainable, making it a very low-cost approach for controlling mosquito-borne viral diseases. The bacterium can be found in up to 60 percent of insects around the world, including butterflies and bees. While not typically found in the *Aedes aegypti* mosquito, *Wolbachia* could be introduced to the mosquito in the lab to prevent the mosquitoes from transmitting Zika virus.

In the study, the research team infected mice with Zika virus originally isolated from a human patient and allowed *Aedes* mosquitoes to feed on the mice either two or three days after they were infected. Four, seven, 10 and 17 days after the mosquitoes fed on Zika-virus-infected blood the researchers tested them for Zika virus infection, assessed whether the virus had disseminated – or spread to other tissues in the mosquito. They found that mosquitoes carrying *Wolbachia* were less likely to become infected with Zika virus after feeding on viral blood and those that were infected were not capable of transmitting the virus in their saliva.

Cinnamon may improve learning ability

Cinnamon, or *dalchini* as it is known in India, is a common spice used widely in cooking for enhancing the taste and flavour of food. Cinnamon has been in use in the preparation of many popular dishes in Asian and Chinese cuisine since ancient times. Along with other spicy items (*masalas*), it is used in marinating chicken, fish and meats. This sweet-flavoured spice is traditionally obtained from the inner brown bark of *Cinnamomum* trees which rolls into tubular-sticks when dried. This novel spice is native to Sri Lanka but also grow in many other countries such as Indonesia, Myanmar, Bangladesh, India, and China.

Several health benefits of cinnamon have been known, including its anti-oxidant, anti-diabetic, anti-septic, local anaesthetic, anti-inflammatory, and anti-flatulent properties. The spice contains health



Cinnamon has been shown to improve learning ability in mice.

benefiting essential oils such as eugenol that gives a pleasant, sweet aromatic fragrance to it. Eugenol has local anaesthetic and antiseptic properties and is often employed in the dental and gum treatment procedures. A recent study with mice by researchers at Rush University Medical Center, Chicago, USA, has shown that cinnamon can also improve the ability to learn (*Journal of Neuroimmune Pharmacology*, July 2016 | DOI: 10.1007/s11481-016-9693-6). According to Kalipada Pahan, the lead researcher of the study, “This would be one of the safest and the easiest approaches to convert poor learners to good learners”.

According to the researchers, the key to understanding the basis of learning lies in the hippocampus, a small part in the brain that generates, organises and stores memory. Researchers have found that the hippocampus of poor learners has less of the

substance called CREB (a protein involved in memory and learning) and more of GABRA5 (a protein that inhibits conductance in the brain) than good learners.

In the study, the researchers orally fed the mice ground cinnamon which their bodies metabolised into sodium benzoate, a chemical used as a drug treatment for brain damage. When the sodium benzoate entered the mice’s brains, it increased CREB, reduced GABRA5, and stimulated the plasticity (ability to change) of hippocampal neurons, which in turn “led to improved memory and learning among the mice”.

To test the improvement in learning ability, the researchers used a Barnes maze, a standard tool used in psychological laboratory experiments to measure spatial learning and memory, to identify mice with good and bad learning abilities. After two days of training, the mice were examined for their ability to find the target hole. They tested the mice again after one month of cinnamon feeding. The researchers found that after a regular dose of cinnamon, the poor learners had improved memory and learning at a level found in good learning mice. However, they did not find any significant improvement among good learners due to cinnamon consumption.

It is known that some people are born naturally good learners, some become good learners by effort, and some find it hard to learn new tasks even with effort. Says Pahan, “Individual difference in learning and educational performance is a global issue. We need to further test this approach in poor learners. If these results are replicated in poor learning students, it would be a remarkable advance”.

Electricity generated from urine

Scientists at the University of the West of England, Bristol, UK, have developed a unique method of turning human urine into electricity with the help of bacteria using microbial fuel cells. Microbial fuel cells represent a completely new method of renewable energy recovery: the direct conversion of organic matter to electricity using bacteria. A microbial fuel cell harnesses the power of respiring microbes to convert organic substrates directly into electrical energy.

The cells are installed inside a container which collects the urine. Inside, bacteria colonise the anode and act as a



The public urinal installed this year at Glastonbury music festival in UK can generate enough electricity to light the cubicle's LED tubes. (Credit: Bristol BioEnergy Centre, University of the West of England)

catalyst, decomposing the organic material in the urine. This decomposition releases both protons, which travel from the anode to the cathode across a semipermeable membrane, and electrons, which travel through an external electrical circuit. To complete the cycle, an oxygen reduction reaction also takes place at the cathode to form only water. The two electrodes are at different potentials (about 0.5 V), creating a fuel cell that needs regular food or “fuel” for the bacteria. The scientists worked on this idea to develop a means of generating electricity at low cost, which could help with combatting dependence on fossil fuels (since urine would be the only fuel needed to run the cell). The process generates enough energy to power LED bulbs or tubes.

According to Irene Merino, a researcher with team, “Our project is aimed at developing countries, with a view to improving or incorporating sanitary facilities. In addition to producing electricity, the system reduces chemical oxygen demand (COD) of waste water; in other words, it also serves to treat the urine”.

So far, the researchers have carried out two field tests: one at the campus of their university, with limited numbers of participants and another at Glastonbury festival – the United Kingdom’s largest music festival – where last year it was tested by around a thousand users per day. In both experiments, the electricity generated was used to illuminate the interior of the cubicle where the urinal was installed. The Glastonbury prototype included 432 cells and generated 300 mW (*Environmental Science: Water Research and Technology*, Issue 2, 2016 | DOI: 10.1039/C5EW00270B).

Now, the researchers are planning

to test these urinals in India or in some regions of Africa in collaboration with Oxfam and other organisations, specifically, in refugee camps, communities, schools and in public toilets that lack lighting. “The ultimate purpose is to get electricity to light the toilets, and possibly also the outside area, in impoverished regions, which may help improve the safety of women and children, in countries where they have to use communal toilet facilities outside their homes,” says Ioannis Ieropoulos, the Director of the Bristol BioEnergy Centre, who

led the research. “This technology is about as green as it gets, as we do not need to utilise fossil fuels and we are effectively using a waste product that will be in plentiful supply,” he adds.

The Periodic Table now has four new names.

Four new elements were officially approved by the International Union of Pure and Applied Chemistry (IUPAC) for inclusion in the Periodic Table earlier this year (*Dream 2047*, March 2016). They bear the atomic numbers 113, 115, 117 and 118. The elements were discovered earlier, between 1999 and 2010. The four new elements were tentatively given the names ununtrium (which means 1-1-3 in Latin), ununpentium (1-1-5), ununseptium (1-1-7), and ununoctium (1-1-8), respectively. Now the four elements have official names proposed by the International Union of Pure and Applied Chemistry (IUPAC).

Element 113, which was discovered at the RIKEN Nishina Center for Accelerator-

Based Science in Japan is to be called nihonium (Nh) after Nihon – a Japanese name for Japan. Moscovium (Mc) is to be the new name for element 115, which was discovered at the Joint Institute for Nuclear Research (JINR) in Dubna, near Moscow in Russia. Element 117, first discovered by a joint Russian-American team in 2010 using samples prepared at Oak Ridge and several universities in Tennessee, will be known as Tennessine (Ts) after the US state of Tennessee, which is home to the Oak Ridge National Laboratory. Element 118 is the only one named after a scientist. It will be known as Oganesson (Og) after the Russian physicist Yuri Oganessian, who led the team at the JINR that discovered element 118.

According to IUPAC, the names are completely in accordance with IUPAC rules. The names now undergo a five-month public

12	aluminum 26.98	silicon 28.08 28.086	phosphorus 30.97	sulfur 32.06 32.065	chlorine 35.45 35.453	argon 39.95	
30	Zn zinc 65.38 65.380	Ga gallium 69.72 69.723	Ge germanium 72.61 72.630	As arsenic 74.92 74.922	Se selenium 78.96 78.960	Br bromine 79.90 79.904	Kr krypton 83.80
48	Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3
80	Hg mercury 200.6	Tl thallium 204.3 204.4	Pb lead 207.2	Bi bismuth 208.9	Po polonium	At astatine	Rn radon
112	Cn copernicium	113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganesson

consultation period. The final decision on adopting the names will be made by IUPAC.

Biman Basu is a former editor of the popular science monthly *Science Reporter*, published by CSIR, He is a winner of the 1994 ‘NCSTC National Award for Science Popularisation’. He is the author of more than 45 popular science books. ■

Dream 2047

Articles invited

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 or e-mail to dream@vigyanprasar.gov.in