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Species Extinctions

INSIDE STORIES

EDITORIAL

Why May?

Nakul Parashar

Yes, May and that too 16 May every year, has been set aside as the International Day of Light by the United Nations Educational Scientific Cultural Organisation (UNESCO). In 1960, on this day, Theodore Maiman, an American physicist, successfully demonstrated the first laser in Manhattan, New York. The laser has since then contributed significantly in the areas of communication, manufacturing, healthcare and much more. Overall, light has been cardinal in the development of science and technology. From Ibn Al Haytham to Einstein and further, light has continuously fascinated the scientists and technologists, opening new scientific frontiers. The entire spectrum of light – from gamma rays to radio waves – provided the required click to our scientists. Consequently, they went on to expand the horizon of their researches. Some of them notable, including advanced research in nanophotonics and quantum optics which have provided our society a new face, an advanced face through sustainable development practices. Photonics is omnipresent – from smartphones in our hands, to fibre optics, space exploration, and satellite monitoring. Indeed, it is a key player in our lives.

In an interesting article published in one of the recent issues of *The Economist*, Technion – Israel Institute of Technology – report an alternative for reorienting a satellite in orbit. Have you ever thought of using a satellite's solar panels to serve double duty as its sails? In order to manoeuvre a satellite in orbit, we've so far been using conventional thrusters like fuel-burning rocket motor and electrically heated gas. The advent of technological advancements has enabled space technologists to use solar panels to their advantage. It was observed that if the satellite is oriented in such a way that its solar panels face the direction of the travel, it would slow down the satellite's motion. On the contrary, if the solar panel is oriented parallel to the direction of motion, then it will speed up. This is the magic of differential drag the application of which has drastically reduced the use of conventional thrusters in manoeuvring satellites. Advantages galore!

Well, May is just not about the International Day of Light. National Technology Day (11 May), World Telecom Day (17 May), and International Biodiversity Day (22 May) are the other major days that fall in the month of May.

Most of us know about the May Day (1 May) but do we know about the significance of the National Technology Day? It is the anniversary celebration of the Pokhran Nuclear Test of 11 May 1998.

Way back in 1865, on 17 May the International Telecommunication Union was formed. Since 1969, this day has been celebrated as the World Telecom Day. The story doesn't end here. In 2005, the UN also declared 17 May as the World Information Society Day. This day was set forth to focus on the importance of ICT and the wide range of issues related to the information society.

Today, when we are equally worried about climate change, we are forced to look towards our flora-fauna, our biodiversity as a focal point. To protect it, several measures are being taken. France, Poland, and many other places have witnessed global summits being held and major resolutions being passed. At Vigyan Prasar too, our team of scientists have come forward to take up issues of climate change and biodiversity quite seriously. A 52-episode radio serial on Akashvani (AIR) was recently launched with the title of 'Whispers of the Wind' (in English) and '*Badalti Fizayein*' (in Hindi). This year, the International Biodiversity Day falls in the proximity of the launch of this serial (docudramas featuring a number of subject experts talking about various issues). Please do tune in to this radio programme and let me have your feedback.

Interestingly, this year's theme of the International Day of Biodiversity is 'Our Biodiversity, Our Food, Our Health'. What a way to end this note – stay alert to protect our biodiversity, eat right and stay healthy.

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Species Extinctions

Felix Bast

It is estimated that more than 99.9% of all species that had ever lived on this planet Earth have gone extinct. While species extinction is an ongoing process as in the case of speciation, some extinction events are truly remarkable and have happened at the global scale resulting a substantial decline in global biodiversity and a large number of species events. These extraordinary extinction events at the global level are called mass extinction events. There are at least five such mass extinction events. There seem to be a consensus that planet Earth is currently undergoing a major, sixth mass extinction, caused almost entirely by human activities.

On 19 March 2018, world's last male northern white rhinoceros (*Ceratotherium Simum Cottoni*) named Sudan (Fig. 1) died at Ol Pejeta Conservancy in Kenya. Now that the world has just two females of white rhino named Najin and Fatu, the extinction of the species is now imminent. We can do nothing to obviate the tragedy in waiting.

It is estimated that more than 99.9% of all species that had ever lived on planet Earth have gone extinct. Out of the rest 0.1% of the extant species (species that are living today), which is currently estimated at around 1 trillion, we know only one thousandth of one percent of them, indicating extreme knowledge gap. It is now estimated that almost half of all extant species will go extinct by the year 2100 even before these species are discovered and characterised.

Extinction, or more specifically 'species extinction,' refers the death of the last member of a species. As the definition is centred on the species, all the ambiguities and problems of species concept also affects the term extinction. Consider the common ancestor of human (Homo) and chimp (Pan) lineages that lived on planet Earth approximately 12 million years ago. Homogenous population of this species might have split into two because of vicariance (the geographical separation of a population, typically by a physical barrier such as a mountain range or river), resulting in a pair of closely related species. However, the exact cause remains unknown, and each of these two populations evolved from common ancestors of either of these two lineages. For example, after the population split into two, the population that evolved into lineage of human beings served as the common ancestor of Homo lineage, not shared with Pan lineage and vice versa with the other population. An intuitive analogy for this allopatric (occurring in areas isolated geographically from one another) speciation is the phenomenon of binary fission (reproduction) that occurs in bacteria. In binary fission, a mother cell splits into two daughter cells. Each of these daughter cells grows in size, and splits into two again. During this split, can we affirm that the mother cell had died? Even if the mother cell prior to binary fission had become non-existent in the form it used to be, the daughter cells are in part made up of the mother cell. Similarly, when a population of one species splits into two and each evolves to different lineages or different species, it is incorrect to call the original species as 'extinct' in the strict sense. This phenomenon is sometimes referred as pseudo-extinction or cladogenesis. A rigorous delineation between these pseudo-extinct species and extinct species is nearly impossible to achieve through paleontological studies. For example, if we study the fossils of this common ancestor of Homo and Pan, we would conclude that this species once existed on planet Earth (perhaps for a span between 1 million and 10 million years) and had gone extinct around 12 million years ago. If we reconstruct the

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evolutionary legacy of these lineages using molecular phylogenetics, we would be able to know that this 'extinct' species is in fact a pseudo-extinct species.

Typical lifespan of a species is around 10 million years (however, this varies widely between different taxonomical lineages; 1 to 10 million years is a better approximation). However, some species greatly outlive this approximation; for example, the so-called 'living fossils'. One example is an ancestor of lungfishes, the Coelacanth. It was believed for a long time that this species had gone extinct at the end of Cretaceous period in the Cretaceous-Paleogene extinction event that also wiped out the planet's dinosaurs. However, in 1938, a South African researcher found this fish at Chalumna River in South Africa. Such species that are thought to have gone extinct but are later rediscovered are called Lazarus taxa. Another example of living fossil is the species of tree called Ginkgo biloba; this species has had virtually no changes for the last 270 million years.

The term extinction is used in ecology to refer the phenomenon of local extinction, when a previously recorded species disappears from a local habitat; this phenomenon is also called extirpation. In many ecosystems, extinction of one species has repercussions on the rest of ecological niche which the extinct species was part of, causing a knock-on effect on several other species. This is especially true if the species that has gone extinct is a keystone species– the species that plays a unique and substantial role in ecosystem function such that without it the whole ecosystem collapses. An example of keystone species is the African elephant in a Savannah ecosystem; if this species goes extinct, the Savannah would turn to woodland, causing widespread effects across the whole ecosystem and initiating a series of extinction events.

An extinct species is often denoted with a dagger symbol (†) in species lists and phylogenetic trees. Many species, including the African elephant, are now on the verge of extinction. IUCN (International Union for the Conservation of Nature) Red List often uses the terms 'threatened' and 'endangered' to denote species on the verge of extinction. A number of species that are extinct in the wild already are now conserved through *ex-situ* mode in zoos and botanical gardens; these species are denoted 'extinct in wild'.

Fig.1. Sudan, the last male northern white rhino which died in March 2018 in Kenya. (Image: Nature/ via Getty)

The big five extinction events and its causes

While species extinction is an ongoing process as in the case of speciation, some extinction events are truly remarkable and have happened on a global scale resulting in a substantial decline in global biodiversity and a large number of species events. These extraordinary extinction events at the global level are called 'mass extinction events'. There have been at least five such mass extinction events well characterised by geologists and palaeontologists till date as the 'big five'. These extinction events were so massive such that well-demarcated rock layers marking the events are found across the world that separates comparatively species-rich layers above and below them. However, note that these mass extinction events are extremely rare in the Earth's deep geologic time; isolated extinction events are much more common. All five big extinction events, therefore, mark the boundaries in the rock layers between respective periods above and below the extinction events. Extinction events might not always be due to higher rates of extinction alone; it could be combined with lower rates of speciation, or entirely due to low rate of speciation. While the exact causes for the big five events differ, the after effect is mostly uniform. They include fluctuations in global climate and sea levels, volcanism and impact events resulting in ejection of toxic gases, ashes and aerosols into the atmosphere causing greenhouse effect, reduction in primary productivity caused by darkened atmosphere, destruction of food chains, and anoxia (depletion of oxygen).

The Ordovician-Silurian (O-S) Extinction event is the second largest of the five mass extinction events. It happened approximately 450 million years ago, and resulted in the extinction of nearly 85% of marine species. A major cause of this extinction event was massive glaciation, the most severe glaciation in the current eon Phanerozoic. The glaciation resulted in the extinction of most of the warm-water species. Among those species that could seek glacial refugia (areas in which a population of organisms can survive through a period of unfavourable conditions) in limited supporting habitats, very low population size of the founding population along with high extent of genetic drift caused elimination of entire ecological niches and extinction of many species. During glaciation, sea levels drop, while during interglacial, it rises again, causing extreme fluctuations. A contrasting hypothesis for O-S extinction event postulate a massive gamma ray burst from a hypernova (a very energetic supernova) 6,000 light years ago from Earth. Even a modest ten-second gamma ray burst would have removed half of the ozone layer, which would result in extinction of several plant species by resulting UV exposure, wreaking havoc at the primary trophic level, affecting entire ecological niche and driving many species to extinction. Yet another contrasting hypothesis states that the cause of global glaciation was volcanic eruptions across the globe. These eruptions deposited silicate rocks around the world, and created entire mountain ranges such as Appalachian Mountains, with predominant siliceous rocks. When these siliceous rocks weathered, it sequestered (removed) CO_2 from the atmosphere that led to reduced greenhouse

effect, global cooling and ultimately the glaciation.

Second of the big five is the Late Devonian extinction that happened approximately 370 million years ago, around the boundary between Devonian and Carboniferous period. This extinction event resulted in extinction of almost 70% of species worldwide, although in terms of extinction intensity, this event was the lowest among the big five. One of the major triggers for this extinction event is now considered to be the plant evolution in Devonian period; from relatively simple plants at early Devonian measuring 30 cm in height with rhizoids that penetrated merely few centimetres of soil layers, vascular plant evolution in Devonian Period resulted in massive trees up to 30 metres in height. Expansive forests of these trees covered much of the landmasses, with two effects. The first and foremost, these deep-rooted trees mobilised deeper soil layers, causing weathering of siliceous rocks as well as nutrient run-off to ocean. As explained in the O-S extinction event, weathering of silicate rocks removed CO_2 from the atmosphere, leading to a major glaciation event, the Late Devonian Glaciation. The nutrient run-off to ocean and limnetic (pertaining to or living in the open water of a freshwater pond or lake) systems resulted in eutrophication (explosive bloom of algae) and finally anoxia wiping out many aquatic species. Second consequence of planet-wide forestation was CO_2 sequestration by these trees through formation of massive coal deposits. As atmospheric CO_2 was removed, global cooling began that finally culminated in the late Devonian Glaciation. The resulting 'icehouse' phenomenon would extend much of the subsequent Carboniferous and Permian periods.

The third mass extinction event, Permian Extinction, happened 252 million years ago, and is the most catastrophic among all five. This 'big dying' event drove almost 96% of all marine species extinct; the biggest in the history of Earth till date. There are several contrasting hypotheses on the possible causes of this event; however, no consensus exists on the exact cause. As the extinction was at such a devastating level, most probably this extinction was triggered by a catastrophic event, such as a large meteor impact or volcanism. Currently the most popular among the hypotheses on the causes of Permian extinction is that an impact by a massive meteor, approximately 250 km in diameter. As the Earth's surface is mostly ocean, covering 72%, probability of asteroid impact occurring on ocean is far higher than that occurring on land. However, as oceanic plates keep on moving, the phenomenon of tectonic subduction is analogous to movement of conveyer belts such that the ocean floor recycles once in every 200 million years. Since this recycling happens everywhere, any crater resulting from any such a massive meteor impact would have been erased by now. An indirect existence of such an impact crater near Falkland Islands near Antarctica was discovered in 1992, as revealed by a circular anomaly in gravity (Fig. 2).

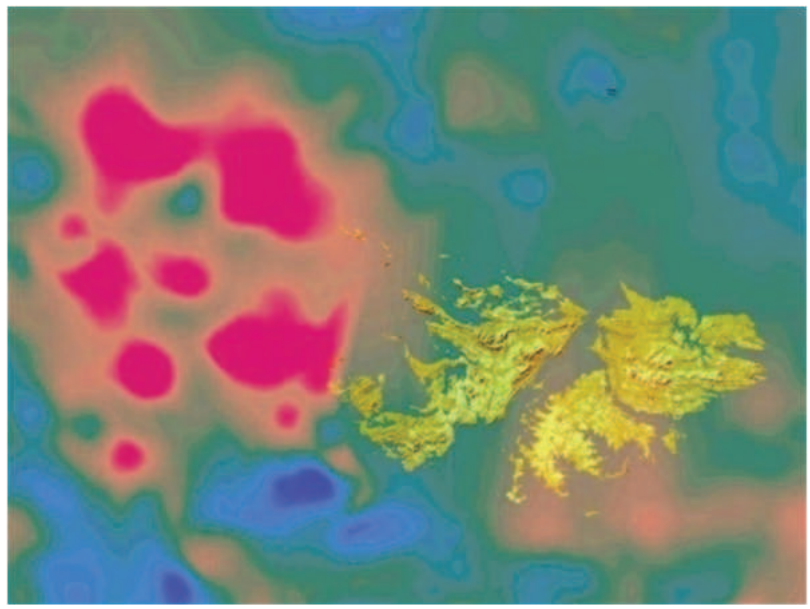

Fig.2. The giant impact crater off Falkland Islands as revealed by the anomaly in gravity. (Image: National Centre for Environmental Information)

Several follow-up researches published later corroborated this early suggestion. Adding on, the landmasses of the world was united into supercontinent Pangea at this time, and such an oceanic impact would have resulted in more severe extinctions in the now-contiguous ocean rather than on land. In fact this event wiped off 96% of all marine species while only 70% of terrestrial vertebrate species were involved. This impact might have triggered extreme volcanic activities at the antipode of impact site, in the Russian Siberia. One of the most expansive igneous deposits on planet Earth, Siberian Traps had been dated to be around this time, perfectly in agreement with meteor impact hypothesis. Extreme volcanism at Siberia might have ejected massive amount of ash, toxic gases and CO_2 into the atmosphere. It would have also caused ignition of massive coal beds that resulted in further rise in CO_2 levels and more atmospheric ash. The dense ash layer might have completely blocked out sunlight reaching the Earth, collapsing ecosystems of both ocean and land. Other hypotheses include release of methane from methane clathrate deposits of ocean floor or by methanogenic bacteria inhabiting benthic zone, global oceanic anoxia, and release of hydrogen sulphide and so on. However, almost all of these events could probably be the after effects of initial meteor impacts, and subsequent volcanic eruptions, rather than the initial cause.

The fourth mass extinction event, Triassic-Jurassic (T-J) happened around 200 million years ago that led approximately 70-75% of all species go extinct. In terrestrial ecosystem, an obvious after effect of this event was that it wiped out competitors for earliest dinosaur species and paved way for the great expansion of dinosaurs in Jurassic Period. In contrast with the rest four, only T-J event was the result of decrease in speciation rate rather than an increase in extinction rate, as revealed by modern research. Background extinction rates remained same during T-J while the rate of speciation decreased tremendously. While a number of causes were hypothesised, as of now no consensus exists. Amongst the hypotheses is gradual climate change along with ocean acidification (ditto of the current day climate change and ocean acidification phenomena), asteroid impact, volcanic eruptions, etc. A possibility is

that series of volcanic eruptions initiated great changes in global carbon cycle that resulted in comparatively high-intensity climate change. An immediate aftermath of this extinction event is the break-up of supercontinent Pangea.

The fifth mass extinction event, Cretaceous-Paleogene (K-Pa, also called Cretaceous-Tertiary K-T) occurred 66 million years ago. This event caused extinction of about 75% of all species of Earth that include all non-avian species of dinosaurs, and caused rapid diversification of mammalian lineage. As this event occurred comparatively recently, there seems to be a good deal of consensus among geologists and palaeontologists about the cause of this event. They key discovery happened in 1980 when Nobel Laureate Luis Alvarez found a layer of iridium with concentrations as high as 160 times that found in nature, in the K-Pa layers from various sites across the world. As iridium is very rare in Earth's surface, he proposed that a major asteroid impact was the initial cause of K-Pa event. In addition, clay layers of K-Pa layer contained microscopic spheres of rock that by all probability formed when molten rock recrystallised inside the clay, suggesting a planet-wide extreme heat immediately after the impact. It is now accepted that a giant asteroid of approximately 180 km in diameter struck the Earth at Chicxulub near Yucatan Peninsula of Mexico (Fig. 3).

The impact created the now famous oval submarine Chicxulub Crater. Consequences of this impact were tremendous; the entry of asteroid itself would have caused a massive heating, instantly killing most of the organisms inhabiting the planet's surfaces. The burning released immense amount of ash and soot that blocked-out Sun, a phenomenon known as 'nuclear winter'. The impact released energy, which is more than a billion times combined energy of two atomic bombs that decimated Hiroshima and Nagasaki in 1945. As the impact site was rather rich in sulphur, the impact released very large amounts of sulphur aerosols into the stratosphere, resulting in planet-wide acid rains, ocean acidification and global cooling, that continued for the next 32,000 years. Mean ocean temperature hovered around 7°C. Ocean acidification killed phytoplankton, organisms having calcareous shells and devastated marine ecosystems. The impact also resulted in mega tsunami that devastated coastal regions around the world. Simultaneous volcanic eruptions at various regions around the globe that happened around this time are now considered to have been triggered by the initial asteroid impact. Amongst these volcanic eruptions is the famous one that resulted in the formation of the Deccan Traps in India.

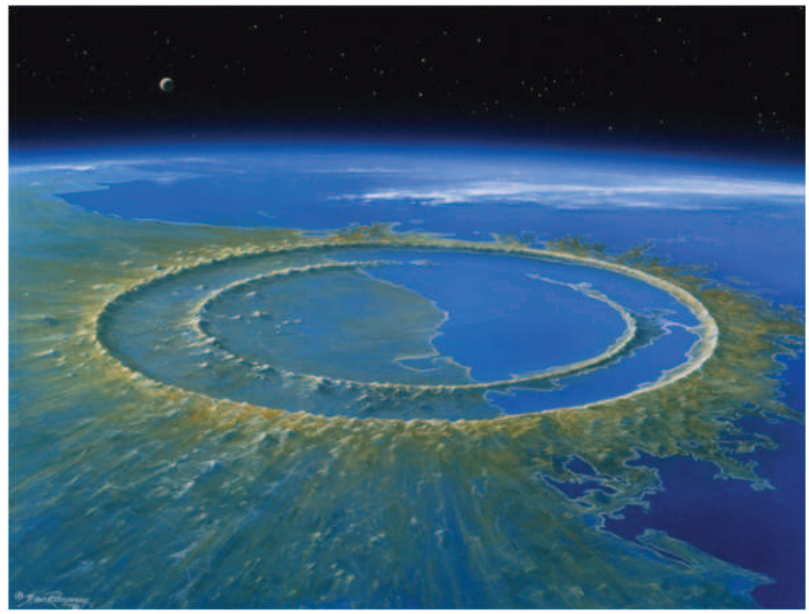

Fig.3. Chicxulub Crater in Yucatan Peninsula, Mexico formed in a massive asteroid impact during Cretaceous-Paleogene extinction event. (Image: New York Times)

HIPPO or the sixth mass extinction at the Anthropocene

There seem to be a consensus that the planet Earth is currently undergoing a major, sixth mass extinction, caused almost entirely by human activities. Effect of human activities since the beginning of the Industrial Revolution in 17th century is so tremendous that it resulted in an extraordinary spike of global CO_2 levels along with other greenhouse gases. The series of events led geologists, climatologists and palaeontologists to propose the beginning of new epoch, Anthropocene, at the end of Holocene that began around 11,500 years ago. There are at least 784 confirmed species extinctions since 1500s. The main causes of this event can be summarised as HIPPO (Habitat loss and destruction, Invasive species, Pollution, human Population, and Overharvesting).

Because of human population expansion and expanding agriculture, a number of pristine habitats have now completely altered. Habitat loss is especially prone in the wetland ecosystems of the world, and a number of endemic species of the wetlands have become extinct. Invasion or introduction by exotic species exerts tremendous pressures for the local species and drive much of the local species to extinction. One famous example is accidental introduction of brown tree snake to the Guam island from Australia during World War II. As Guam had no snakes and therefore no snake predators until then, the exotic snake species could thrive there that led to destruction of most of the local bird species. Other examples include introduction of feral dog Dingo to Australia 4,000 years ago that drove extinction of several marsupial species, and introduction of rats into Mauritius by Dutch sailors that ate eggs of endemic flightless bird Dodo. Pollution, especially by synthetic chemical pesticides, has caused extinction of a number of key amphibian and insect species throughout the world. World's aquatic fauna is especially prone to over harvesting; it is now estimated that by 2150 almost the entire species of marine and freshwater fishes would go extinct. Despite its threatened status, a number of whale species of the world continue to be hunted by countries including Japan and Norway. Human population explosion has caused almost the all of these associated problems, including habitat loss, species invasion, pollution, and overharvesting.

5G: The Next Generation of Cellular Technology

Dr. P. K. Mukherjee

High-speed mobile network is required to sustain exponential growth of Internet of Things (IoT). The next generation of cellular technology, called 5G, may be a possible solution. 5G technology is expected to bring a new revolution in the field of mobile communication and will change the way network coverage is provided to the subscribers. There are some challenges like globally acceptable standards; handset configuration, etc. that need to be resolved before 5G becomes a standard mode of mobile communication. Till then, older technologies 4G, 3G, and even 2G will not lose their utility.

In a few years' time you will be able to download a full-length high definition (HD) movie to your phone in a matter of seconds rather than minutes. And video chats will be so immersive that it will feel like you can reach out and touch the person right through the screen.

Certainly, you are going to embrace a more connected world with Internet of

Things (IoT) expected to grow exponentially over the next ten years or so. The IoT refers to the billions of physical objects around the world that are connected to the internet, collecting and sending data. The IoT adds a level of digital intelligence to devices that would be otherwise dumb, enabling them to communicate without human involvement, and merging the digital and physical worlds. It will need a network that can accommodate billions of connected devices. All this will become possible with the next generation of cellular technology, called 5G.

While it is expected to bring much faster data and download speed on your mobile phones, it will also open door to a lot of different consumer and industrial applications and uses–some of which seem unbelievable now because they are so futuristic. Let us have a quick look at the different generations of cellular telecommunication.

Different generations of cellular phones

The first generation, called 1G mobile technology, was introduced in 1980s. It was analogue in nature and had a low bandwidth of 30 kHz. Functioning on circuit switching principle, 1G service could provide voice calls only. Its speed was limited to 2.4 kilobits per second (kbps) and offered very low levels of spectrum efficiency. The size of the devices used with 1G technology was quite large. Therefore, mobile phones based on this technology were not handy; they could only be installed in cars etc.

The second generation (2G), based on digital technology, was started in Finland in 1991. This mobile technology had a higher channel bandwidth (30-200 kHz) and was significantly efficient on the spectrum as compared to 1G technology. Besides voice calls, it offered services, such as SMS, text messages, picture messages and MMS (multimedia messaging service). The 2G technology offered service with a speed of 64 kbps. All text messages sent over 2G phones are digitally encrypted. This allows transfer of data in such a way that only the intended

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receiver can receive and reach it. So, it has greater data security than offered by 1G.

The third generation (3G) technology brought about a quality change in the voice and text messages. It had a much higher bandwidth (15-20 MHz) as compared to 1G or 2G technology. This technology uses circuit switching for voice calls and packet switching for sending data and text messages. Services like web browsing, email, video downloading, picture sharing, etc. are offered by 3G with data transfer speed varying from 384 kbps to 2 Mbps (Megabits per second).

The first 3G network was launched in Japan in October 2001 by NTT DOCOMO. Thereafter, via South Korea and Europe this technology reached the US in 2003. By December 2007, one hundred ninety 3G networks were operating in forty countries of the world. With Bharat Sanchar Nigam Limited (BSNL) offering its services in Bihar, 3G technology was introduced in India in the year 2008. Then, in 2010, MTNL brought 3G service to Delhi and Mumbai.

The fourth generation (4G) mobile service brought about a revolution in the field of mobile telecommunication. This technology totally functions on packet technology for voice calls as well as for sending data and text messages. It offers a bandwidth of 100 MHz and can have a minimum speed of 100 Mbps, which can go to the maximum limit of 1 Gbps (Gigabits per second). These are, however, theoretical limits. In India, the practically available 4G speed is typically between 2 and 10 Mbps with different networks providing different speeds. Although 4G was introduced in 2009, no network was officially designated as 4G before 2011. Of course, there were some devices which were designated as 4G, but they did not fulfil the standards fixed by the International Telecommunication Union (ITU). In 2011, only LTE-A (Long Term Evolution-Advanced) and WiMax Release 2.0 were officially designated as 4G.

The 4G mobile technology operatesat high frequency (2-6 GHz) and has a bandwidth of 100 MHz. It has about double the download speed of 3G. The high speed of 4G makes it

appropriate for high-speed applications such as high-definition (HD) mobile TV, video conferencing and 3D TV, etc.

5G mobile technology: key goals

The fifth generation (5G) of mobile communication targets high data rate, reduced latency, energy saving, cost reduction, higher system capacity and massive device connectivity. Today, 5G is purely a concept as the global standard for this technology is yet to be finally evolved. Obviously, the global standard for 5G has to be in tune with the key goals of 5G.

One of the key goals to be achieved with 5G technology is far better levels of connectivity and coverage and data rate of

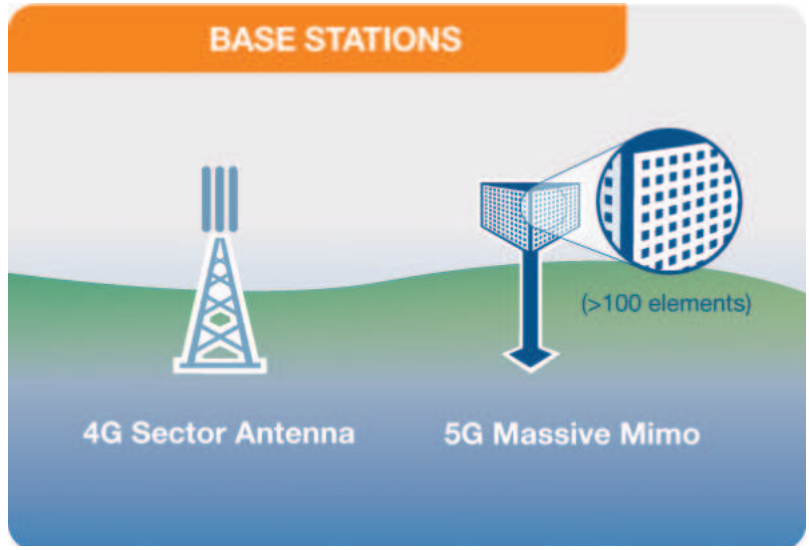
10 Gbps. In contrast, the 4G networks currently in service can achieve peak data rate of 1 Gbps though in practice it is never that fast. To have an idea of how fast 5G will be compared to 1G, let us take the video example. 5G allows downloading of an 8 gigabyte HD movie in 6 seconds compared to 7 minutes it would take with 4G and more than an hour with 3G.

Another key goal with 5G technology is ultra-low latency. "Latency" refers to the time it takes one device to send a packet of data to another device. Currently, with 4G, the latency rate is 50 ms (milliseconds); but 5G will reduce it down to less than 1 ms. This will be particularly important for activities requiring quick response, such as virtual reality (VR), 4 k video streams, driverless cars, factory robots, Internet of Things (IoT), online gaming and broadcast-like services. It will also aid life-line communication in times of natural disaster.

Challenges in the way of 5G

Other than the challenge for evolving a globally acceptable standard for 5G, much higher bandwidth-possibly 1-2 GHz-also poses new challenges for handset development where a maximum frequency of around 6 GHz and bandwidth of 100 MHz are currently in use. The 5G technology operates under a frequency spectrum which is much higher than that of the 4G technology and has never been used for mobile before. While 4G operates at frequencies of 2-6 GHz, 5G operates between 3-300 GHz. Such higher frequencies are bound to present some real challenges in terms of the circuit design, the technology, and the way the system is used. As frequency is inversely proportional to wavelength, using such high-frequency radio waves means that the waves operating in this region are millimetre (mm) waves. The problem with millimetre waves is that they are unable to cross solid objects. Therefore, buildings or trees act like obstacles for these waves. Even bad weather like rain or presence of humidity in air can cause interference and consequent absorption of waves. As a result, the waves suffer a great

deal of attenuation leading to the weakening of the signal with distance. The ultimate result of this absorption of the waves by the obstacles coming in their way is poor connectivity. In order to offset this, mini base stations are required to be set up near big network towers to transmit signals, avoiding the obstacles. These low-powered base stations catch the signal from the big towers and sense the frequency to transfer the signals to communication devices (mobile phones, etc.).

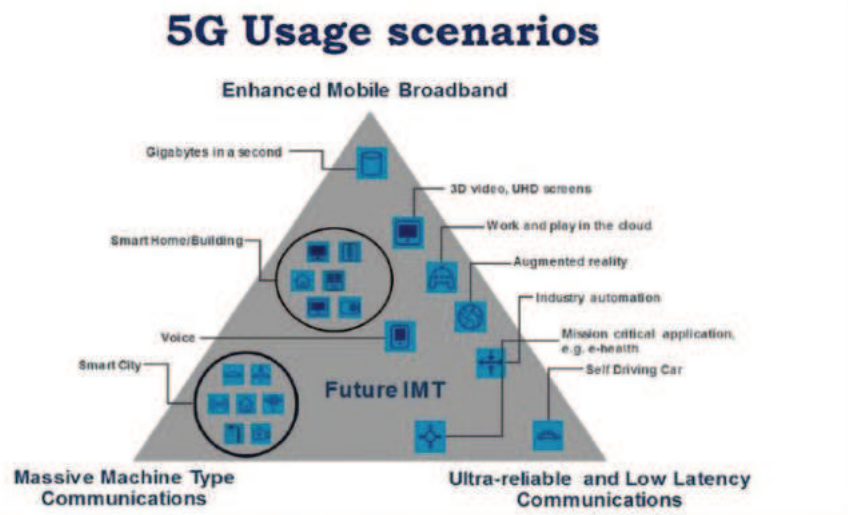


Along with base stations, antenna technology with Massive MIMO (Multiple Input and Multiple Output) needs to be pressed into service. The term Massive MIMO was first coined by the Nokia Bell Labs researcher Thomas L. Marzetta in 2010. The concept is to use large antenna arrays at base stations to simultaneously serve many autonomous terminals. This reduces errors and also increases the efficiency of a network. However, installing antennas with such characteristics will be a huge task towards building of infrastructure for 5G. Further, issues around spectrum, which had already been witnessed with 4G, are also likely to crop up,

Fixing standard for 5G

The standard for 5G has not been finalised yet. Therefore, first the standard has to be finalised before the first networks based on this standard can be rolled out. This is necessary because pre-standard networks bring their own sets of problems as had been the experience with 4G also. The work on development of a global standard and technologies for 5G has been going on with standard bodies including the 3GPP, ITU and IEEE as well as universities, public bodies and special interest groups, all having their inputs.

One needs to wait and see which global standard is finally going to be accepted. In the meantime, research on developing the technologies for 5G has been going on in many institutions, organisations and even universities of many countries. In 2012, the UK government announced funding of $70 million for building a 5G research centre, known as 5G Innovation Centre (5GIC) at the University of Surrey. This is the world's first research centre set up specifically for 5G mobile research.



India's way forward

As far as India is concerned, the government is confident of rolling out 5G in tandem with global markets in 2020 (although experts in IT area are sceptic and predict the year to be 2022) and is making all efforts to keep the timeline for the next generation technology, which could have an economic impact of more than $1 trillion in the country. The Department of Telecommunication (DoT) is pushing hard to bring 5G to India as soon as it is available for commercial roll-out globally. In June 2018, DoT had invited Ericsson, Nokia, Samsung, Cisco and NEC for deployment of 5G applications and running trials on the suggestion of Stanford University Professor Arogyaswami J. Paulraj. Paulraj is a member of the 5G panel that recently suggested spectrum roadmap for the technology. DoT had wilfully excluded China telecom equipment vendor Huawei for these trials, though earlier, in February 2018, Huawei had conducted 5G trials in laboratory with Bharti Airtel in India, where it achieved broadband speed of more than 3 Gbps in 3.5 GHz spectrum band. As of October 2018, it was claimed by Jay Chen, the chief executive officer (CEO) of Huawei India, that DoT has again invited them to conduct trials in busy and dense areas of two cities of India including Delhi.

There is no gainsaying the fact that the advent of 5G in our country will bring new revolution in the field of mobile communication and will change the way network coverage is provided to the subscribers. But, older technologies 4G, 3G and even 2G will not totally lose their utility. Many people in rural areas are still using 2G networks. High-speed internet is still something unknown to them. We will have to wait and see how the things unfold after 5G comes to the country. But it is certain that 5G technology will bring revolutionary change in the field of cellular telecommunication.

The Incidence of Hospital-acquired Infections in India

Megha Panpalia Machhar

Health care centres across the globe bear the burden of hospital-acquired infections. In comparison to adults, new-borns are at higher risk of contracting hospital-acquired infections. A cooperative effort is required to keep the situation in check. Every hospital should constitute an 'infection control committee'. The waste generated from the hospitals is a potent source of infection. Stringent measures are required for proper disposal of hospital wastes. The Indian Council of Medical Research under its Antimicrobial Stewardship Programme has released a manual on Hospital-Acquired Infection Control Guidelines.

Patients go to a hospital to get cured, but often they contract infections that lead to prolonged hospital stay, increased financial stress, morbidity, and mortality. Hospital-acquired, or nosocomial infections is a matter of serious concern for hospitalised patients, doctors, and the health care staff.

Hospital-acquired infections are a common occurrence worldwide affecting both high- and low- income countries. According to World Health Organsation (WHO), of every 100 hospitalised patients at any given time, 7 in developed and 10 in developing nations will acquire at least one health care-associated infection. New-borns are at a higher risk of contracting hospital-acquired infections with high incidence – approximately 20 times higher in developing countries (like India) as compared to developed countries (like the USA).

Types of hospital-acquired infections

Central line-associated bloodstream infection: These infections result in thousands of deaths every year with an incidence rate of 12-25%. A central line or central venous catheter is a tube that doctors often place in the large vein in the neck, chest or groin region to give medications or collect blood for various tests. These catheters access major veins close to the heart and are placed for long durations. They are mostly used in intensive care units. Due to their prolonged use they can cause serious bloodstream infections According to a research published in the *International Journal for Quality in Health Care* in February 2017, the overall rate of central line-associated bloodstream infection of patients in ICU in northern India was found to be 17.04 per 1,000 catheter days and 14.21 per 1,000 in-patient days, with median duration of hospitalisation of 23.5 days and the median duration for which central venous catheter was placed at 17.5 days.

Catheter-associated urinary tract infections: It is the most common type of acquired infection globally. Eighty per cent of the cases are associated with bladder catheters. The tube inserted serves as channel for entry of bacteria and as some of the urine stays in tube, it helps in bacterial sustenance. In India, catheter-associated urinary tract infections account for more than 30% of the infections reported by hospitals.

Surgical-site infections: After catheter-associated urinary tract infections, surgical-site infections are the second most common type of hospital-acquired infections. The incidence depends upon the type of surgery the patient is undergoing and his/her current medical status. Surgical-site infections are mostly caused by bacteria already present in the body.

Ventilator-associated pneumonia: Hospital-acquired pneumonia largely hits patients admitted in the intensive care units and put on ventilator. The infection

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surfaces nearly after 48 hours of the placement of a flexible plastic tube into the trachea (windpipe). The infecting bacteria may be endogenous or exogenous; colonising the stomach, upper airways and bronchi, leading to pneumonia.

Besides the above-mentioned hospital-acquired infections which are more frequent, other infections can affect skin and soft tissues, cause inflammation or swelling of the tissue lining the sinuses (sinusitis), inflammation of the inner lining of the uterus (endometritis), or inflammation of the lining of the intestines caused by a virus, bacteria or parasites, most common in children (gastroenteritis).

The hospital acquired pathogens

Bacteria, viruses, fungi and parasites are the main sources of hospital-acquired infections, bacteria being the most common of all. The type responsible varies based on different patient conditions, health-care facilities and the surrounding environment.

Bacteria: The commensal bacterial population of the natural microbial flora can cause infection when the person's immune system is compromised. For example, *Bacteroides fragilis*, found in intestinal tract and colon, causes infection with other bacterial species. Intestinal *Escherichia coli* causes urinary tract infections. *Acinetobacter* is mainly responsible for infections in intensive care units. *Staphylococcus aureus* causes a variety of lung, bone, and bloodstream infections. Methicillin-resistant *Salmonella aureus* and *Klebsiella spp.* are highly resistant to antibiotics, further aggravating the problem. They can easily spread among patients and hospital staff.

Viruses: Viruses constitute 5% of all hospital-acquired infections. They can easily infect both patients and staff through hand, mouth, endoscopes, transfusions, dialysis and injections. Hepatitis B and C virus can be transmitted through unsafe injection practices. Other viruses include rotavirus, herpes simplex virus, varicella-zoster virus, HIV, etc.

Fungi: They are opportunistic pathogens that target immune-compromised patients. *Candida albicans* and *Cryptococcus neoformans* are the major cause of systemic infections. *Aspergillus spp.* are found in dust and construction sites that contaminate the hospital surroundings, causing infections.

Parasites: Parasites, like fungi, are also opportunistic pathogens. *Giardia lamblia* spreads easily among adults and children. It colonises small intestine and causes giardiasis. *Sarcoptes scabiei,* is an ectoparasite that often causes outbreaks in health care centres. This arthropod burrows under the skin and causes scabies.

Many types of parasites can affect humans

Epidemiology of hospital-acquired infections

Health care centres across the globe - be it in high-income, middle- or low-income countries - bear the burden of hospital-acquired infections. The scale of burden is of course, more inclined towards the middle- and low-income nations. The prevalence of health care-associated infections in developed part of the world ranges from 3.5% to 12%. The European Centre for Disease Prevention and Control has reported the incidence rate of 7.1% in European countries, with 17 incidences per 1,000 patient days while the United States has an incidence rate of 4.5%, with an average of 9.3 infections per 1,000 patient days. The prevalence rate of hospital acquired infections in low- and middle-income countries varies from 5.7% to 19.1% and the frequency of the infection is an average of 42.7 episodes per 1,000 patient days - almost three times that of high-income nations.

In comparison to adults, new-borns are at higher risk of contracting hospital-acquired infections. The prevalence rate is 3-20 times higher in underdeveloped and developing countries than in developed countries. Hospital-acquired infections are responsible for 4% to 56% of all casualties in hospital-born babies in developing countries.

The average rate of hospital-acquired infections in India is 5% to 10%, with high prevalence rate in patients admitted in ICUs. The incidence of catheter-associated urinary tract infections is 28%, surgical-site infections 19%, ventilator-associated pneumonia is 17%, and central line-associated bloodstream infection is 7% to 16%.

Determinants of hospital-acquired infections

There are several risk factors that determine the incidence of hospital-acquired infections. The environment inside and surrounding the health care setting should be hygienic, pollution-free and green. Unhygienic ambience and poor waste disposal facilities account for most hospital-acquired infections. The hospital staff should also be well versed with latest techniques, proper use of invasive devices like catheter tubes, injections, and basic infection control measures. Immune-compromised patients

are at higher end of the scale. Prolonged stay in the hospital and extended use of antibiotics are also major contributors in the list.

A study conducted by International Nosocomial Infection Control Consortium, led by Dr. Victor D. Rosenthal in 2015 revealed that the prevalence of hospital-acquired infections in India is far higher than those reported by the Centres for Disease Control and Prevention (CDC) in the United States. One of the major issues responsible is overcrowding, which roots various other problems. The daunting ratio of doctors and hospital staff to the number of patients has only worsened the situation. Overpopulated hospitals lead to poor hygiene practices. With one nurse for three beds in ICU, the prevalence rate goes up.

Lack of efficient administration and financial constraints, particularly in government hospitals, have only worsened the situation. Also, not all hospitals are properly accredited and hence there always exists some serious loopholes in their practices of government-set rules, regulations and protocol.

How hospital-acquired infections can be controlled

A cooperative effort is required to keep the situation in check. A cumulative endeavour of doctors, nurses, other hospital staff and general public visiting the health care facility can give fruitful results in combating the problem. Every hospital should constitute an 'infection control committee' that should undertake various prevention, control and training programmes for dealing with hospital-acquired infections. The guidelines, precautionary measures and hygiene practices formulated by the expert panel of the committee should be strictly followed.

The manpower of the health care facilities should be adequately increased to tackle the overcrowded patient population. With requisite workforce, strong and efficient cadre of nurses, housekeeping, maintenance and laboratory technicians can be built up. The infection control committee should also regulate various vocational training programmes for hospital staff to strengthen their technical IQ, safety measures and hygiene practices. Also, they should be updated with the latest techniques being developed and be competent at it. A strong management team should also be commissioned for review, approval and implementation of the various policies formulated by the committee.

The waste generated from the hospitals is a potent source of infection. Stringent measures should be taken for proper disposal of hospital wastes. All the surgical instruments and other hospital accessories should be regularly and rightfully autoclaved. Sanitation and aseptic environment should be of utmost importance in health care facilities as these are the alpha point of the maximum infectious agents.

The Indian Council of Medical Research under its Antimicrobial Stewardship Programme has released a manual on *Hospital-Acquired Infection Control Guidelines*. Its proper implementation and practice would be a valuable tool for curbing the problem of hospital-acquired infections.

An efficient surveillance strategy is the need of the hour

The infection rate of a hospital is an indicator of its quality of care and safety measures to keep the contagion in check. And for the infection rate to be at its minimum it is important to develop a surveillance stratagem. Surveillance is an information-based activity that involves the collection, analysis and interpretation of large volumes of data originating from a variety of sources.

The first step involves the collection of data. A vast data pool is created by trained data collectors. They muster demographic risk factors, record of procedures and devices that can be a source of infection, patient details such as admission date, clinical history, laboratory reports, medical and nursing chart review, presence or absence of infection, onset of symptoms, microorganisms involved, antimicrobial susceptibility and other diagnostic test results.

In view of current environmental conditions, poor air and water quality, population growth and antimicrobial resistance, the task of eliminating incidences of hospital-acquired infections seems to be insurmountable. But, proper waste management strategy, bio-safety regulation, training of nursing staff, appropriate hygiene practices and greater public awareness would help in tackling the situation in apt manner, with the ultimate aim of providing quality care to the patients. ■

Neuroscience and Science of yoga: Its implication in mental health

Anurag Tripathi

Yogic practices enhances overall concentration and memory and boosts emotional and spiritual intelligence, which is key to success and is measured in terms of emotional quotient (EQ) and spiritual quotient (SQ) respectively. Emotional intelligence helps us counter stress condition and enhances societal connectivity, while spiritual intelligence makes us realise our global and cosmic connections and makes us real human beings.

Neuroscience is the area of study related to neurons – highly specialised cells that constitute the brain of different organisms, particularly organisms with higher level of organisation, including humans. In the past few decades this branch of science has grown at a fastest pace and is now established as an area of interdisciplinary study with its ramified branches such as neuro-anatomy, neurochemistry, neurophysiology, neurology, neuropsychiatry, neural networking, connectomics (related to study of diverse and complex neuronal connections of brain), and of late as neuro-marketing, neuro-management, neuro-economics, neuro-informatics and artificial intelligence (electronic gadgets endowed with intelligence akin to that of humans). If cognitive and behavioural function of the brain is also incorporated, study of psychology and philosophy is also needed to comprehend it in entirety. Recently yoga has received ample validity in scientific community to rewire neuronal connections, balance neurochemicals and hormones and overall in improving the quality of life.

Brain, mind and human consciousness

Human brain is the most complicated and most sophisticated organ of the universe, comprising approximately 100 billion neurons and supporting glial cells, which are many folds greater in number. How the brain and mind are correlated to each other has remained a debatable issue for long; mind is a psychological term and is the consequence of distinct neuronal processes and pathways within the brain. If brain is compared to the hardware of a computer, mind is akin to its software. Thus to recognise the brain-mind correlation let us have a brief insight into the fascinating world of the brain.

The human brain is a very complex structure from anatomical, physiological and behavioural point of view. Itis a highly crumpled structure consisting of many small grooves (sulci), ridges (gyri) and deep grooves (fissures), visible from outside. It is divided into frontal, parietal, temporal and occipital lobes, each responsible for distinct functions in quite integrated and coordinated fashion through scrupulous neural networks that are highly plastic in nature and keep on rewiring with new inputs of learning. Recently, highly sophisticated tools and techniques like functional magnetic resonance imaging (f-MRI), positron emission tomography (PET), and brain scanning have enabled the neuroscientists to map specific brain centres involved in a particular behaviour or action, such as perception of colour or identification of objects and faces, to mention a few. It has been experimentally proven than millions of neurons, located in different brain areas and connected to each other through scrupulous neuronal circuits, are involved during a particular action. Distinct sets of neurons located in different areas of the brain are called nuclear groups and such nuclear groups are intricately connected

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to one another through complex circuits, giving rise to a new area of neurological study called 'connectomics'. Thus a complex neuronal network is activated during any action, thought or behaviour, connecting the specific brain areas through distinct and dynamic neuronal pathways.

Each neuron is connected to other neighbouring neurons through nearly ten thousand or more synaptic connections for the transmission of nerve impulses through electrochemical signalling. Further, each neuron is individually entangled with 10 to 50 supporting glial cells which are highly diverse in nature morphologically and functionally. Recently, glial cells have been reported to assist in nerve conduction also, in addition to their role in providing support and insulation to neurons.

Due to these complex electrochemical neural processes various inputs of information are perceived through our sense organs and are processed, consolidated and stored in various brain centres. The information is further processed to generate a particular thought, idea, perception or behaviour, which is collectively considered as 'mind'. Thus mind is the manifestation of the brain. Whatever we do or whatever we think it is due to our mind, which is programmed to act in a particular way. Thus by changing our thought process we can change our mind, or in other words we can rewire our brain. It is worth mentioning here that our thought process or psyche also regulates the level of neurochemicals, which further regulate the physiological condition of the brain and body. Consciousness is a state of mind when we are fully aware of our thought process or we have control over our mind. In neurological term during conscious state of mind, the prefrontal cortex, the front part of the brain (frontal lobe), which is the executive part of brain, gets activated and exerts its effect over rest of the brain through distinct neuronal connections.

Science of yoga

Yoga is a central component of the comprehensive system of Indian philosophy known as Vedic science. Seer Patanjali defines yoga as "*yogas chitta vritti nirodhah*", which means 'having control over mind is yoga'. In modern science, it is well documented and there are numerous research papers in the scientific domain that qualify yoga as a proper science of connecting and balancing the different systems of body and attaining the highest state of consciousness. Our body system works through an axis which is called 'psycho-neuro-immuno-endocrine axis'. By breaking up the term psycho-neuro-immuno-endocrine into its parts we can see psycho- (from psychology), neuro- (from neurology), immuno- (from immunology), and endocrine- (from endocrinology – the study of hormones).This relationship reveals that our psyche or thought process regulates our nervous system, which further regulates our hormonal system and immunity.It has been established that our immune system is accountable not merely for defence but also for boosting the brain and enhance mood. These systems regulate the entire physiology of the body including digestive system, circulatory system, urinogenital system (the urinary and reproductive systems) are a few to name. For a healthy and balanced life, proper balance among the different systems is essential, which can be achieved through yogic practices.

The term yoga is derived from Sanskrit root '*yuj*', which means 'to unite'. Thus yoga is a state of mind when mind, body and spirit get united. Spirit can be defined as the state of pure consciousness which can be felt in a peaceful and thoughtless state beyond the intellect. There are different dimensions of life. Physical body or '*annamaya kosh*' is the physical domain comprising aforementioned systems of the body which is under the regulation of neuro-endocrine system. Next level is '*pranamaya kosh*', which means sheath made of vital energy. The source of energy flow in body system is breathing. That is why proper attention is paid in yogic practices to control this system through '*pranayam*' or breathing exercises. The word *pranayam* is derived from '*prana*' which stands for 'life force' and '*ayama*' which means 'to lengthen or to work on it'. *Prana*, in yogic terms, means the force within the body that is vital for the functioning of the body as well as its vitality.

The next dimension of life in yogic science is at the level of mind or '*manomaya kosh*', which is the compilation of diverse thoughts in the form of memory. In psychological term it is called subconscious mind which controls 90% of our activities and behavioural patterns. In yogic science it is the key level to be practised and brought under control. Once it is controlled we perform most of the subconscious activities consciously. Ceaseless processing of stored memory in cortical centres forms intellect, which is termed in yogic science as '*vigyanamaya kosh*'. Most people live and behave at this level, which is reflected in form of intelligence quotient (IQ), but it is attached to ego or '*ahamkara*' in yogic terms. The highest dimension of life in yogic science is '*anandmaya kosh*' or the state of eternal blissful divinity when we get detached from our thought process and go beyond intellect, and reach the level of wisdom. At this level, our ego is abolished and we feel connected to every object of the universe, which is explicable in terms of spiritual quotient (SQ). Spiritual quotient is described as a measure that looks at a person's spiritual intelligence in the same way as intelligence quotient looks at cognitive intelligence. At this yogic dimension the philosophy of '*adwaita*' or a-dualism of ancient yogi *Shankara* can be realised. This is the highest state of consciousness where we feel cosmic connection.

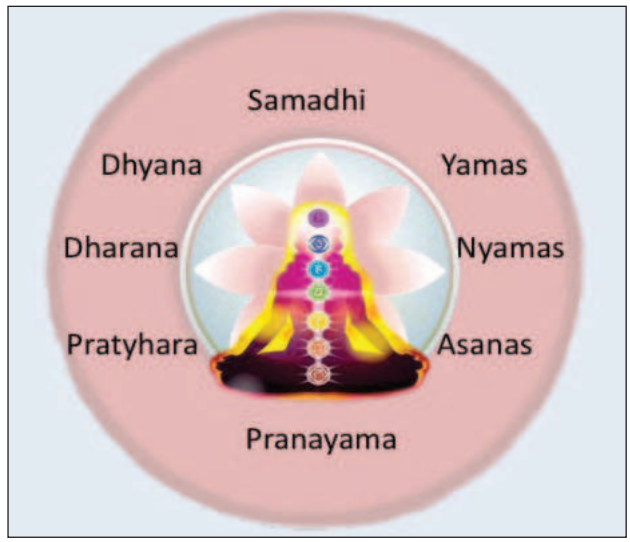
Various forms of yoga

Yoga is not merely physical exercise or certain body poses; it is the state when our body, mind intellect and spirit get united and synchronised. The crux of yoga is meditation, but it cannot be attained unless we are physically fit, calm and have regular and deep breathing pattern. Thus to attain this state '*astanga*' yoga is the best practice given by seer Patanjali. This form of yoga which is also called '*sahaj*' yoga finds proper description in ancient scriptures *Bhagvad Gita*, and *Yoga sutra*. It involves eight yogic practices, which are *yam, niyam, asana, pranayam, pratyaahar, dhaarana, dhyana and samadhi*. *Yam* is the significant practice where attention is paid to *satya* (truth), *ahimsa* (nonviolence), *asteya* (not stealing), *aparigrah* (not storing extra materials), and *brahmcharya* (control over desires). In *niyam* (rules of personal behaviour), five practices are involved, which are purity, contentment, discipline, spiritual exploration, and surrender to the divine. In *asana* or body pose, certain body postures with proper breathing rhythm are made to keep the body system fit and healthy which is prerequisite to attaining meditative state. *Pranayam* is the key practice to regulate breathing pattern and proper circulation. Deep breathing, *kapalbhati, anulom-vilom* and *bhramari* are the common practices of *pranayama*. Through this practice the neuro-endocrine system gets orchestrated to balance the rest of the body systems. In *dhaarana* practice, sense organs are withdrawn from external surroundings and are focussed inwards at the mind level and we can explicitly watch what is going on in the mind at thought level.

In meditation, which is the pith of yoga, focus is on breathing pattern after sitting in a cross-legged straight position. Energy level rises from lower to higher centres of energy located in the distinct parts of the spinal cord and brain which are called *chakras* in yogic science. In the deep meditation state, our mind becomes thoughtless and a proper rhythm is accomplished effortlessly among different dimensions of vitality. And finally the highest state of yoga, *samadhi* or purest form of consciousness is attained. If it is practised regularly for at least one hour up to 45 days under the guidance of trained yoga and meditation expert, it becomes a habit and gives fruitful results. In *Bhagvad Gita*other forms of yoga such as *gyana yoga, karma yoga,* and *bhakti yoga* are also mentioned that one can conceive by going through this scripture.

Table-1

CHAKRAS	NEURAL ASSOCIATION	HORMONAL ASSOCIATION
First-Root	Sacral plexus	Adrenal gland
Second- Creativity	Lunar plexus	Reproductive glands
Third- Energy	Solar plexus	Pancreas(insulin)
Fourth-Heart	Cardiac plexus	Thymus gland
Fifth-Expression	Cervical plexus	Thyroid gland
Sixth-Intution	Carotid plexus	Pituitary gland
Seventh-Consciousness	Cerebral plexus	Pineal gland



Yoga and mental health

'Mindfulness meditation' involves the process of developing the skill of bringing one's attention to whatever is happening in the present moment. It is a great way to increase focus, decrease stress, and stimulate creativity. In recent years, a lot of research has been going on to study yoga and mindfulness meditation and results of the studies have found place in scientific journals, particularly in neuropsychiatric journals. In modern hectic and technology-fed era, there has beena spate in cases of mental disorders like anxiety, depression, and brain stroke, and neurodegenerative disorders like dementia, schizophrenia, and Parkinson's disease. These neurological disorders result in additional ailments like diabetes, hypertension, and gastro-intestinal illnesses because our physiological condition is connected to neuroendocrine health. These ailments can be cured by regular practice of yoga and meditation. In prominent mental health centres including National Institute of Mental Health and Neuropsychiatry (NIMHANS), Bangalore and Ranchi Institute of Neuropsychiatry and Social Studies (RINPASS), Ranchi, mindfulness meditation and yogic practices are done as an alternative medication. It boosts up immunity and enhances the level of neurochemicals endorphins like gamma amino butyric acid (GABA) in brain, which relaxes the brain and gives exuberant feeling. In yogic practices, level of the neurohormone oxytocin is enhanced which gives empathetic and compassionate feeling. Enhanced level of serotonin and dopamine eradicates depression, stress and suicidal tendency. Yoga enhances the level of an important chemical called brain derived neurotrophic factor (BDNF), which is considered as the fertiliser of brain that boosts neuro-regenerative process and permanent memory. Mindfulness meditation turns the mind from being turbulent to being creative and ignited. Yogic practices enhances overall concentration and memory and boosts emotional and spiritual intelligence, which is key to success and is measured in terms of emotional quotient (EQ) and spiritual quotient (SQ) respectively. Emotional intelligence helps us counter stress condition and enhances societal connectivity, while spiritual intelligence makes us realise our global and cosmic connections and makes us real human beings. ■

Recent Developments in Science and Technology

Biman Basu

There have been wide speculations about the presence of water on Mars with occasional evidence from space missions. Now European Space Agency's Mars Express has revealed the first geological evidence of a system of ancient interconnected lakes that once lay deep beneath the Red Planet's surface, five of which may contain minerals crucial to life. On the surface, Mars appears to be an arid world, but its surface shows compelling signs that large amounts of water once existed across the planet.

How Hubble and Gaia weighed the Milky Way

There have been wide speculations about the presence of water on Mars with occasional evidence from space missions. Now European Space Agency's Mars Express has revealed the first geological evidence of a system of ancient interconnected lakes that once lay deep beneath the Red Planet's surface, five of which may contain minerals crucial to life. On the surface, Mars appears to be an arid world, but its surface shows compelling signs that large amounts of water once existed across the planet.

Weighing the Milky Way in the conventional way – by putting it on a scale – is certainly an absurd idea. But astronomers found a way to do it – by measuring the three-dimensional movement of objects called globular star clusters in our galaxy and have come up with one of the most accurate measurements yet of our galaxy's mass. Halo globular clusters contain considerably more stars and are much older than the less dense galactic, or open clusters, which are found in the disk of a galaxy. According to astronomers, globular clusters contain the oldest known stars, dating back to a few hundred million years after the big bang, the event that created the universe. They formed prior to the construction of the Milky Way's spiral disk, where our Sun and solar system reside.

Using NASA's *Hubble Space Telescope* and the European Space Agency's *Gaia* satellite to measure the three-dimensional movement of Milky Way's globular clusters, an international team of astronomers led by Laura Watkins of the European Southern Observatory in Garching, Germany has come up with a figure of about 1.5 trillion (10^{12}) times the mass of our Sun as the mass of the Milky Way (*Astrophysical Journal*, 12 March 2019).

But only a few per cent of this is mass contributed by the approximately 200 billion stars in the Milky Way and includes a 4-million-solar-mass supermassive black hole at the centre. Most of the rest of the mass is in the form of dark matter, an

Hubble Space Telescope

invisible and mysterious substance that acts like scaffolding throughout the universe and keeps the stars in their galaxies.

Although we cannot see it, dark matter makes up almost 90 per cent of the total mass of the universe and it can be weighed through its influence on visible objects like the globular clusters. The more massive a galaxy, the faster its globular clusters move under the pull of gravity. Most previous measurements have been along the line of sight to globular clusters, so astronomers know the speed at which a globular cluster is approaching or receding from Earth. However, *Hubble* and *Gaia* could record the sideways motion of the globular clusters, from which a more reliable speed (and

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therefore gravitational acceleration) can be calculated.

According to the astronomers, earlier research dating back several decades used a variety of observational techniques that provided estimates for our galaxy's mass ranging between 500 billion to 3 trillion solar masses. The current measurement is near the middle of this range, which the astronomers say is fairly normal for a galaxy of its brightness.

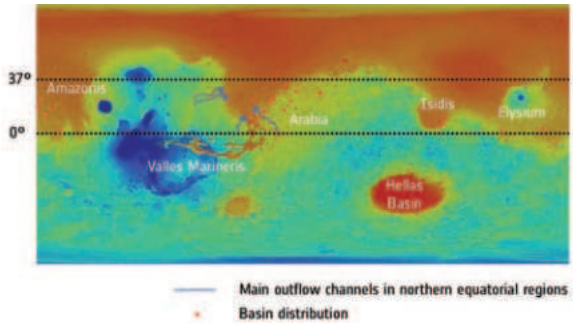
According to the astronomers, the *Hubble* and *Gaia* observations are complementary. *Gaia* was exclusively designed to create a precise three-dimensional map of astronomical objects throughout the Milky Way and track their motions. It made exacting all-sky measurements that include many globular clusters. *Hubble* has a smaller field of view, but it can measure fainter stars and therefore reach more distant clusters. The new study augmented *Gaia* measurements for 34 globular clusters out to 65,000 light-years, with *Hubble* measurements of 12 clusters out to 130,000 light-years that were obtained from images taken over a 10-year period.

First evidence of planet-wide groundwater system on Mars

There have been wide speculations about the presence of water on Mars with occasional evidence from space missions. Now European Space Agency's *Mars Express* has revealed the first geological evidence of a system of ancient interconnected lakes that once lay deep beneath the Red Planet's surface, five of which may contain minerals crucial to life.

On the surface, Mars appears to be an arid world, but its surface shows compelling signs that large amounts of water once existed across the planet. There are features that could have been formed only in the presence of water, such as branching flow channels and valleys, for example. Last year *Mars Express* detected a pool of liquid water beneath the planet's south pole (*Dream* 2047, September 2018). A new study now reveals the extent of underground water on ancient Mars that was previously only predicted by models (*Journal of Geophysical Research: Planets*, 21 January 2019 | DOI: 10.1029/2018JE005802).

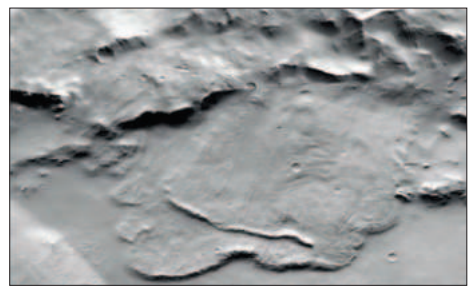
According to Francesco Salese of Utrecht University, the Netherlands, who led the study, "Early Mars was a watery world, but as the planet's climate changed this water retreated below the surface to form pools and groundwater. We traced this water in our study, as its scale and role are a matter of debate, and we found the first geological evidence of a planet-wide groundwater system on Mars".



This image shows the distribution of deep craters (marked as dots) recently explored as part of a study into groundwater on Mars. The background image is shown in colours representing topography: reds and oranges are lower elevations, and blues and greens are higher ones. The study found that the floors of the basins, which sit over 4,000 m deep, show signs of past water – the first geological evidence that the Red Planet once had a system of interconnected groundwater-fed lakes that spanned the entire planet. (Credit: Topography: NASA/MGS/MOLA; Crater distribution: F. Saleseet al. 2019)

The new finding is based on a detailed study by Salese and colleagues of 24 deep, enclosed craters in the northern hemisphere of Mars, with floors lying roughly 4,000 m below Martian 'sea level' (a level that, given the planet's lack of seas, is arbitrarily defined on Mars based on elevation and atmospheric pressure, where the zero elevation is defined by the mean Martian radius of 3382.9 kilometres).

They found features on the floors of these craters that could only have formed in the presence of water. Many craters contain multiple features, all at depths of 4,000 to 4,500 m – indicating that these craters once contained pools and flows of water that changed and receded over time.



Example of features identified in a deep basin on Mars that show it was influenced by groundwater billions of years ago. (Credit: NASA/JPL-Caltech/MSSS)

Other features they discovered included "channels etched into crater walls, valleys carved out by sapping groundwater, dark, curved deltas thought to have formed as water levels rose and fell, ridged terraces within crater walls formed by standing water, and fan-shaped deposits of sediment associated with flowing water".The water level aligns with the proposed shorelines of a putative Martian ocean thought to have existed on Mars between three and four billion years ago.

Says Gian Gabriele Ori, director of the Università D'Annunzio's International Research School of Planetary Sciences, Italy, who was also part of the study team, "These lakes would have existed around 3.5 billion years ago, so may have been contemporaries of a Martian ocean".

The team also spotted signs of minerals within five of the craters that are linked to the emergence of life on Earth, such as various clays, carbonates, and silicates. According to the researchers, the finding adds weight to the idea that these basins on Mars may once have had the ingredients to host life. Moreover, they were the only basins deep enough to intersect with the water-saturated part of Mars' crust for long periods of time, with evidence perhaps still buried in the sediments today.

Exploring sites like these in future missions may reveal the conditions suitable for past life and are therefore highly relevant to astrobiological missions such as *ExoMars* – a joint ESA and Roscosmos endeavour. While the *ExoMars Trace Gas Orbiter* is already studying Mars from above, the next mission will launch next year. It comprises a rover – recently named after Rosalind Franklin – and a surface science platform and will target and explore Martian sites thought to be key in the hunt for signs of life on Mars.

Mars Express was launched on 2 June 2003 and reached 15 years in space last year. The current study used observations from the High-Resolution Stereo Camera (HRSC) on ESA's *Mars Express*, the High-Resolution Imaging Science Experiment (HiRISE) and the Context Camera on-board NASA's *Mars Reconnaissance Orbiter*. A digital terrain model was used based on data from the HRSC and NASA's *Mars Orbiter* Laser Altimeter. ■

Kolkata Book Fair-2019

Kolkata book fair is considered Asia's largest book fair. Millions of book-lovers visit this book fair. The Publishers & Booksellers Guild organized the 43rdInternational Kolkata Book Fair from 31 January to 11 February 2019.

Vigyan Prasar participated in the Kolkata Book Fair this year in collaboration with Bose Institute, one of the autonomous institutes of the Department of Science & Technology, Govt. of India.Almost all the titles including recently published books were available in the Vigyan Prasar stall. Children and science club coordinators were interested in the books of Vigyan Prasar. One Kolkata-based Ham enthusiast and several scientists and school teachers also visited the VP stall. During the book fair, around 5,000 visitors came to the VP stall. Dr. Manish Mohan Gore represented Vigyan Prasar in the Kolkata Book Fair-2019.

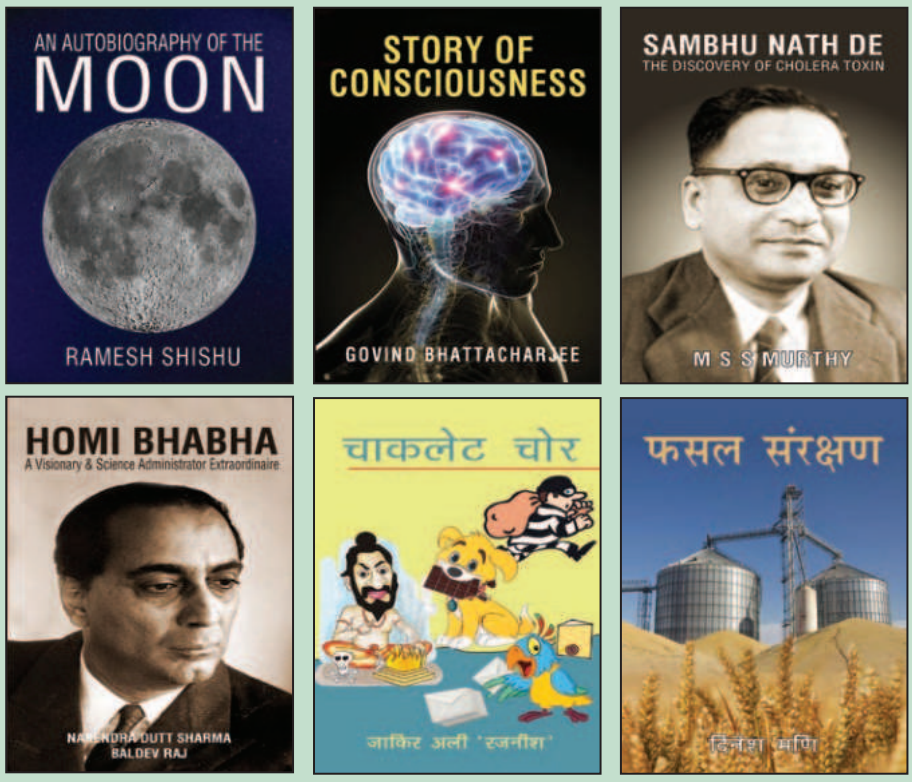
Science Exhibition at Kanpur

Vigyan Prasar brings out books and monographs on several themes of science and technology. The organisation regularly participates in leading book fairs/science exhibitions of the country to reach out to its audience and readers. The huge gatherings in such fairs and exhibitions reflect the peoples' interest in the popular science books of Vigyan Prasar.

During 27-28 January 2019, Vigyan Prasar had put up a book stall in a Science Exhibition at Sankhahari, Ghatampur, Kanpur (U.P.), where Shri Shakti Degree College had organised a two-day National Seminar on "Need for Research and Innovation in Teaching Methodology".The Seminar was sponsored by National Assessment & Accreditation Council (NAAC). The organising committee invited Vigyan Prasar to put up a stall of its publications so that delegates, academicians and research students could be familiar with the contribution of Vigyan Prasar in science communication as well as its various publications. There were more than 200 visitors to this stall. Dr. Vinay Trivedi of Shri Shakti Degree College coordinated the science exhibition and ShriWasiullah Khan represented Vigyan Prasar there.

(Reported by Dr. Manish Mohan Gore) ■

NEW RELEASES



VP website

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