News for Oct.-Dec. 2018

SCIENCE AND TECH.

THE CRUX OF THE HINDU

Vol. 16

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About the 'CRUX'

After the success of our monthly magazine The Crux of The Hindu and PIB, we are introducing a new and convenient product, to help the aspirants for various public services examinations. Today, the knowledge of the Current Affairs (Science and Technology) constitutes an indispensable tool for all the recruitment examinations. However, as per the examinations are concerned, it is quite tedious task to memorise each and every news. Moreover, every news as given in magazines and newspapers may or may not be relevant from exam perspective which forces the candidates to spend a quality time in extracting useful matter and framing notes. This problem of aspirants strikes our minds and made us to think for a sure shot solution as a result of which our experts have come out with the unique magazine of Science and Technology, Crux of Science and Technology. This trimonthly convenient product is going to save our aspirants' time. The whole concept of the CRUX is to provide you with a summary of the important news and current affairs, from an exam point of view. By reading the CRUX, you will be able to save your precious time and effort, as you get all the relevant matter in a summarized and convenient form. The Crux is particularly helpful for the Civil Services, Banking, SSC and other exams that have a current affairs section. The material is being provided in such a manner that it is helpful for both- objective and descriptive sections. Our aim is to help the candidates in their effort to get through the examinations. Your efforts and dedication inspire us to keep going. It is our sincere effort to make your journey easier.

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Glitch puts NASA's Chandra telescope in 'safe' mode

Barely a week after NASA's Hubble Space Telescope entered safe mode, the Chandra mission has also suffered a glitch possibly due to the failure of the gyroscope, the US space agency said.

The Chandra X-Ray Observatory, observing the universe in high-energy light since 1999, has entered a protective 'safe mode', which interrupts scientific observations and puts the spacecraft into a stable configuration.

"At approximately 9:55 a.m. EDT on Oct 10, NASA's Chandra X-ray Observatory entered safe mode.

"The cause of the safe mode transition (possibly involving a gyroscope) is under investigation," NASA said in a statement.

Safety measures

During the safe mode, the observatory is put into a safe configuration, critical hardware is swapped to back-up units, the spacecraft points so that the solar panels get maximum sunlight, and the mirrors point away from the Sun.

"Analysis of available data indicates the transition to safe mode was normal behaviour for such an event. All systems functioned as expected and the scientific instruments are safe," it added.

Expectations

Chandra, launched in 1999, is well beyond the original design lifetime of 5 years. In 2001, NASA extended its lifetime to 10 years. It is now well into its extended mission and is expected to continue carrying out forefront science for many years to come.

Meanwhile, the U.S. space agency said that it continues to work towards resuming science operations of the Hubble Space Telescope.

On October 5, Hubble entered safe mode after one of the three gyroscopes (gyros) being used to point and steady the telescope failed. Gyroscopes help spacecraft maintain proper orientation.

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Scientists are currently performing analyses and tests to determine what options are available to recover the gyro to operational performance.

Till then, science operations with Hubble have been suspended.

GROWTH-India telescope's first science observation

The 0.7 m GROWTH-India telescope at the Indian Astronomical Observatory located in Hanle, Ladakh, has made its first science observation which is a follow-up study of a nova explosion. Novae are explosive events involving violent eruptions on the surface of white dwarf stars, leading to temporary increase in brightness of the star. Unlike a supernova, the star does not go on to die but returns to its earlier state after the explosion. A report on this published in The Astronomer's Telegram notes the magnitude of the nova explosion first identified by Darnley et al as it varies, during November 8 to November 10.

First science observation

The GROWTH-India telescope was commissioned six months ago soon after which it saw first light, on the night of June 12. "The telescope has been taking readings since then, and this is the first 'follow-up' work. We are happy to see this first science observation," said G C Anupama, who Professor-in-Charge of the Indian Astronomical Observatory and is based at Indian Institute of Astrophysics (IIAP), Bengaluru.

The celestial object was first noticed by a different group which saw the nova explosion. "We then pointed our telescope in that direction and measured the brightness. We found that it was fading at the rate expected for such events. This is a small step in astronomy but a big leap for us, because it is the first scientific result obtained by this telescope," said Varun Bhalerao a faculty member at IIT Bombay and a Principal Investigator of the project along with Professor Anupama.

This recurrent nova, named M31N-2008, has been observed to erupt several times, the most recent eruption happening in November 2018. Recurrent nova systems are interesting because they are candidates for progenitors of Type Ia supernovae.

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"We took follow-up images with the GROWTH-India telescope. The observations were made in different optical bands. The nova was seen to decline rapidly in brightness, by 1 - 1.5 magnitudes in the span of 2 days," says Shubham Srivastav, post-doctoral fellow at the physics department of IIT Bombay (IITB)

Robotic eye

The telescope is potentially fully robotic and can operate on its own, but the way these readings were taken has only partly used its potential for automation. "The group sitting in IIT Bombay worked through Bengaluru's IIAP to control the telescope. While the IITB-IIAP link was through regular internet connection, the one from IIAP to the telescope in Ladakh was through a satellite link," said Professor Bhalerao. A typical professional telescope has a field of about 0.1 square degrees.

This telescope has a field that is five to six times larger. It can 'slew' or move its focus from one part of the sky to another in just about 10-15 seconds and its camera can view stellar objects that are thousands to millions of light years away.

Threefold goals

The GROWTH-India telescope is part of the Global Relay of Observatories Watching Transients Happen. Its goals are threefold: (1) Search for explosions in the optical regime whenever LIGO group detects a Binary Neutron Star merger (2) study nearby young supernova explosions. (3) Study nearby asteroids.

Transient phenomena such as supernovae are important parts of time-domain astronomy which is a less-explored frontier in astronomy. "Such an explosion is when the inner material of the star is thrown out. There is no other way we can actually see what is inside a star," explains Prof. Bhalerao.

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On the cosmic ray trail in Tirunelveli

"They installed these huge towers and we stopped getting rains," says K. Vijayalakshmi, a resident of Krishnapuram village pointing at the MF Radar antennas (30 m tall towers) at the Equatorial Geophysical Research Laboratory (EGRL), Tirunelveli.

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The four antenna towers that Vijayalakshmi pointed to, though creating a panic among the locals have nothing to do with rains. They are part of atmospheric radar that helps study the winds at heights between 70 km and 100 km above the Earth.

Located at a distance of 11 km from Tirunelveli, EGRL, spread over an area of more than 35 acres, is a regional centre of the Indian Institute of Geomagnetism (IIG), Mumbai. A multi-disciplinary centre with instruments to measure the Earth's magnetic field variations and various atmospheric parameters, the facility has been continuously monitoring the Earth's near-space environment for over 25 years now.

"Like the surface winds that we are familiar with, winds in the upper atmosphere too are highly variable. Understanding what causes those variable winds has been a primary focus of study at EGRL," explains Dr. Sathishkumar, associate professor at the laboratory. "Lower atmospheric disturbances like severe weather events can have their signatures in the upper atmosphere, too. We are trying to establish the teleconnection between distant regions of the atmosphere and their impact on regions up to 100 km height and beyond."

Why Tirunelveli?

Tirunelveli is in close proximity to both the geomagnetic and geographic equator. When experimental activities at the centre first commenced in 1991, the geomagnetic equator passed right through the city.

When winds blow, electric currents are expected to be produced in the electrically charged upper layers of the atmosphere across the geomagnetic field. Over Tirunelveli and the adjoining regions, where the geomagnetic field is horizontal the current flowing primarily in the east–west direction would be enhanced. Scientists call this current 'Equatorial Electrojet' and probing this helps scientists understand the Sun–Earth connection.

Secondary cosmic ray study

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Another major experimental facility recently set up at EGRL is meant to monitor secondary cosmic rays. When the cosmic rays — from supernovae, colliding galaxies and spinning black holes — enter the Earth's atmosphere, they lose their energies through collisions with our atmospheric molecules and produce a cascade of subatomic particles known as secondary cosmic rays.

"There is a significant anti-correlation between solar activity and the intensity of the cosmic rays. There is also a debate about whether secondary cosmic rays can trigger earthquakes and volcanic activity", explains Dr. C.P. Anil Kumar, Head at EGRL.

Answers from Antarctica

Besides the magnetometer network in Indian landmass, IIG routinely operates magnetometers in the Indian stations in Antarctica, namely, Maitri and Bharati.

"The importance of monitoring the geomagnetic field over Antarctica is that it is the polar region where the magnetic fluxes are dense and where the Sun's particle effects are first felt on Earth," explains Mr. K. Jeeva, Technical Officer at EGRL.

Whenever the Sun's activity becomes violent — for example, during a solar flare or during episodes of coronal mass ejections — the Earth's magnetic field would readily encounter energetic particles.

"A chain of events takes place in the Earth's electromagnetic environment following a solar event resulting in electrical currents at high altitudes and heating of the upper layers of the atmosphere over Antarctica. Such intense overhead currents are responsible for ground-induced currents that can create havoc for the underground telecommunication lines and electrical power grids," explains Dr. Jeeva.

IIG also operates a suite of instruments at Antarctic stations to understand the impact of the disturbances on the Sun on the Earth's environment.

Besides the traditional magnetometers, IIG also operates induction coil magnetometers to sense the extreme low-frequency signals produced by global thunderstorm/lightning activity. "Antarctic continent is free from local or regional

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lightning activity. The Indian Antarctic stations are thus ideal sites to monitor global fluctuations in lightning activity," Dr. Jeeva adds.

Monitoring the electromagnetic signatures simultaneously from Indian continental landmass and the Antarctic enables the scientists to understand the hidden teleconnections between the polar and equatorial regions. Moreover, such studies throw light on space weather, a scientific and technological domain affecting the very many man-made satellites orbiting the Earth and the instruments on board used for a variety of purposes.

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Scientists design fabrics that can store charge

A major factor holding back development of wearable biosensors for health monitoring is the lack of a lightweight, long-lasting power supply. Now, scientists at the University of Massachusetts Amherst in the US have developed a method for making a charge-storing system that is easily integrated into clothing.

"Batteries or other kinds of charge storage are still the limiting components for most portable, wearable, ingestible or flexible technologies. The devices tend to be some combination of too large, too heavy and not flexible," said Trisha L Andrew, who led the study published in ACS Applied Materials & Interfaces.

The method uses a micro-supercapacitor and combines vapour-coated conductive threads with a polymer film, plus a special sewing technique to create a flexible mesh of aligned electrodes on a textile backing.

The resulting solid-state device has a high ability to store charge for its size, and has other characteristics that allow it to power wearable biosensors.

While researchers have remarkably miniaturised many different electronic circuit components, until now the same could not be said for charge-storing devices.

"We show that we can literally embroider a charge-storing pattern on to any garment using the vapour-coated threads that our lab makes," said Andrew.

Researchers are working on incorporating the new embroidered charge-storage arrays with e-textile sensors and low-power microprocessors to build smart garments that can monitor a person's gait and joint movements throughout a normal day.

IISER Pune's novel anode increases Li-ion capacity, quickens charging

A novel anode developed by researchers at Indian Institute of Science Education and Research (IISER) Pune for use in lithium-ion batteries has five times more capacity than carbon-based electrodes and can be fully charged in about 15 minutes. The team led by Satishchandra Ogale from the Department of Physics at IISER Pune used a composite made of phosphorene (few-layer black phosphorus) and silicon nanoparticles to fabricate the anode.

Unlike carbon-based anodes that have a theoretical capacity limit of just 372 mA

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h per gram, silicon has 10-12 times higher limit (4,200 mA h per gram). Yet, it has proved very difficult to fully harness the potential of silicon to make electrodes for Li-ion batteries. The reason: when lithium forms an alloy with silicon, the alloy undergoes massive volume expansion of up to 300% during charging. The huge and repeated volume expansion and contraction (during discharging) breaks the electrode thus making it highly unstable and hence unfit for use in a battery.

Improved stability

While other teams have used graphene sheets to encapsulate silicon nanoparticles to absorb the stress and prevent the anode from cracking, the improvement in stability has not been satisfactory. While using up to 40% graphene has not solved the problem, IISER Pune researchers used just 8% of phosphorene to dramatically improve the stability of silicon electrode.

Stable electrode

The stability was so good that the electrode made of silicon-phosphorene mixture showed no discernible cracks even after 250 cycles of charging and discharging. In comparison, electrodes made of silicon nanoparticles alone developed cracks soon after 20 cycles.

“Phosphorene has exceptional flexibility due to its low Young’s modulus and so can absorb huge stress that comes when silicon expands. The flexibility comes from the puckered structure of phosphorene where it looks wrinkled or folded,” says Kingshuk Roy from the Department of Chemistry at IISER Pune and first author of a paper published in the journal Sustainable Energy & Fuels.

Elaborating on the choice of phosphorene, Prof. Ogale says: “Unlike graphene that is a sheet-like material which is difficult to deform or mechanically stretch, the folds of phosphorene are like the accordion instrument. This allows phosphorene to absorb the stress when silicon expands and contracts during every cycle of charging and discharging.”

The silicon-phosphorene anode was prepared by physically mixing the dispersions of silicon nanoparticles and chemically exfoliated sheets of few-layer black phosphorus.

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The silicon-phosphorene mixture was then coated on a copper foil to make it behave as an anode. “The structure and elasticity of phosphorene helped in retaining the integrity of the electrode,” says Prof. Ogale.

What makes the anode made of silicon-phosphorene composite particularly important is that the capacity remained high at 1,600 mA h per gram even after 250 cycles of charging and discharging. “The charge capacity was as high as 1,100 mA h per gram even when we increased the current density to 4 A per gram,” says Dr. Malik Wahid from the Department of Chemistry at IISER Pune and another first author of the paper. “This means, the battery can be fully charged in say 15 minutes.”

However, when the current density is reduced to 0.5 A per gram, the capacity increases to 1,600 mA h per gram. So when the battery is charged slowly for about 60 minutes, the capacity increases to 1,600 mA h per gram.

Capacity retention

After 250 cycles, there was 65% retention of capacity, which is huge for silicon. In comparison, the capacity retention is 70-75% in the case of carbon. “But the reversible capacity of carbon electrodes is five times less compared with silicon,” Roy clarifies.

Under high magnification, the researchers found phosphorene was uniformly covering the silicon nanoparticles. “So whenever silicon expanded by volume during charging, the phosphorene was able to absorb it thus retaining the integrity of the anode,” says Roy.

“We are planning to make a full cell by using silicon-phosphorene composite as the anode and a commercially available cathode. We are also working to innovate on the cathode,” says Prof. Ogale.

ATOMIC ENERGY

On the tracks of the Earth’s mantle helium

Helium – the second most abundant element in the universe – is hard to come by on Earth in its gaseous state, because it is so light that it can escape easily. But one of the places where it is found is in volcanic lava plumes, such as seen in Iceland and Hawaii, originating from the Earth’s mantle. This is ancient helium from when the Earth was formed. It is believed to be trapped in compounds deep within the earth.

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However, the nature of these compounds have so far remained a mystery.

Now a group of researchers has come up with a striking possibility that the mantle helium must exist as the compound FeO2He which is stable and solid under the pressure and temperature conditions prevailing at those depths.

The team used a crystal search algorithm CALYPSO which they had developed, to look at possible compounds containing helium. If the energy of the suggested compound containing helium was lower than that of free helium, then the compound state would be considered favoured and the algorithm would give a positive answer. In this manner, looking at many hypothetical magnesium and iron based compounds, the team came up with just one possibility – FeO_2He.

Stable at the mantle

Their calculations showed that this compound is stable at temperatures between 3000 K and 5000 K and at pressures between 135 and 300 GPa. These conditions correspond to those found in the core–mantle boundary.

If this result is proved right by experiment, it will solve the longstanding problem of where ancient helium is stored within the Earth.

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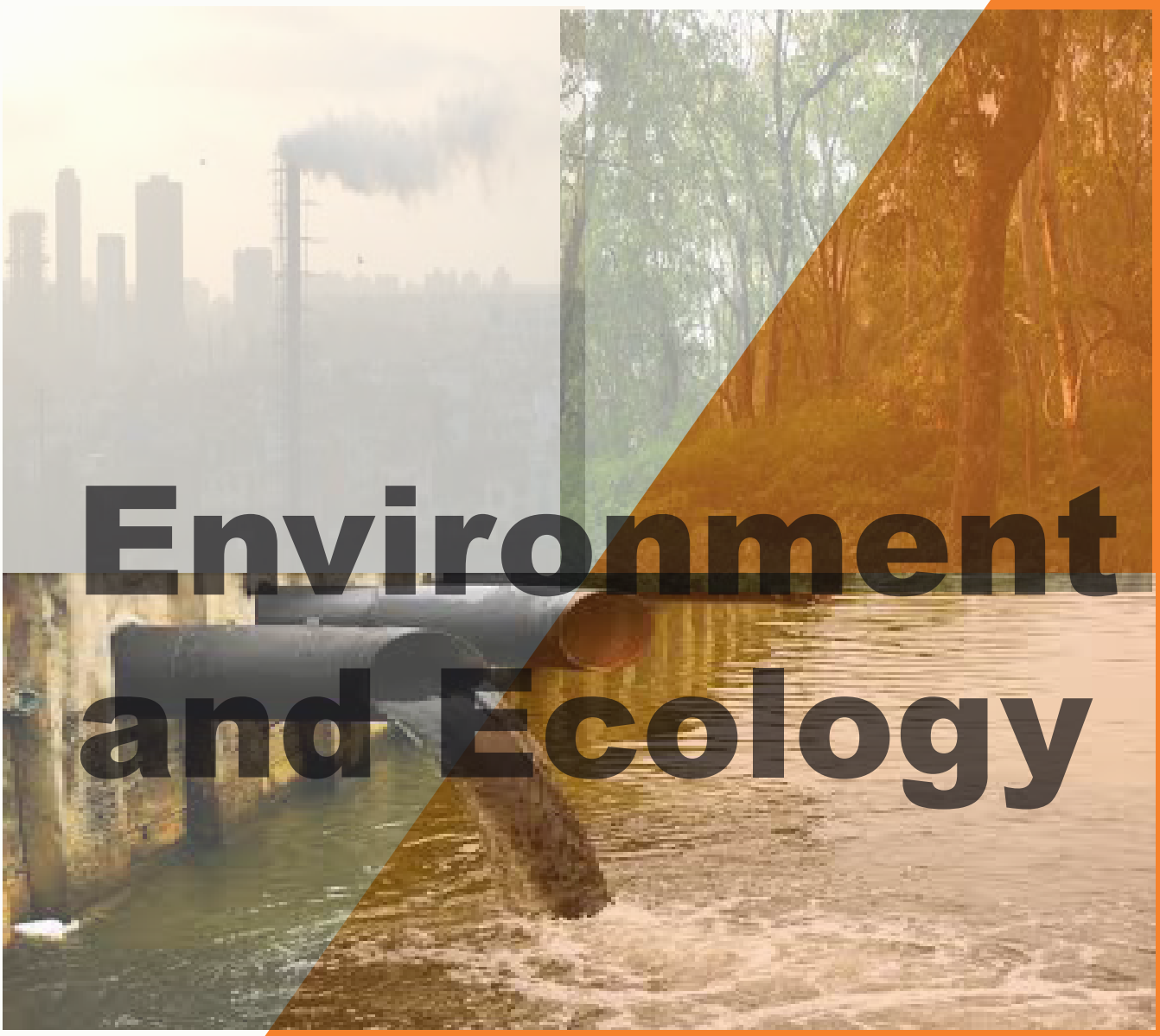

Environment and Ecology

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Common ant pollinates rare wild jamun

Bees might be the most well-known pollinators, but researchers have found that common white-footed ants are the best pollinators of a rare evergreen tree in the southern Western Ghats.

Syzygiumoccidentale is a small, wild jamun tree that grows mostly along the banks of the River Periyar in Kerala. It is categorised as 'vulnerable' by the International Union for the Conservation of Nature. The survival of such a species is crucial, depending on the fruits it produces, which is only possible if pollinators fertilize its flowers first.

To find out which animals — birds, bats, wasps or bees — are its most important pollinators, researchers from institutes including Kerala's Central University studied the flowering patterns and timings of around 50 trees that grow along the River Periyar. Visiting the trees daily for three separate flowering seasons between 2010 and 2015, the team quantified the timing of flowering, the volume of nectar available in flowers, the animals that visit the flowers and the frequency of their visits.

They found that 10 species — including sunbirds and cockroaches — visited the large, pleasant-smelling white flowers that bloomed between December and April. Among these, seven species (including bees and two ant species) frequented the flowers the most.

The team then conducted experiments to determine which species was the most effective pollinator. They permitted only one type of pollinator (white-footed ants, weaver ants, night-flying insects, birds or day-flying insects such as bees) to visit freshly bloomed flowers for around two days by using combinations of net bags and glue to keep out other animals during this time. They also tested for the efficacy of wind pollination by using mosquito nets to eliminate all pollinators from visiting the flowers.

After each experiment, the researchers dissected the fruit to confirm the presence of healthy, embryo-carrying seeds: proof that a particular animal group had successfully pollinated the flower. Their results, published inArthropod-Plant Interactions, shows

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that ants — especially white-footed ants, the most frequent visitors to the flowers day and night — were the most efficient pollinators of the tree.

This is an interesting finding because ants are usually depicted as poor pollinators. Unlike the white-footed ants, many flower-visiting ant species (such as the weaver ants in this study) attack other pollinators and thus prevent them from pollinating the plant, said co-authors P. A. Sinu from the Central University of Kerala and K.R. Shivanna (Ashoka Trust for Research in Ecology and the Environment).

Eastern Ghats face loss of forest cover, endemic plants

The Eastern Ghats spread across Odisha, Andhra Pradesh, Karnataka and Tamil Nadu, has lost almost 16% of its forest area over a span of 100 years, a recently published study shows.

Researchers from the University of Hyderabad studied historical maps and satellite images from 1920 to 2015 to understand the changes in land use and land cover. The forest cover, which was 43.4% of the total geographical area in 1920, has reduced drastically to 27.5% in 2015. Over the years, about 8% of forest area was converted into agricultural fields, while about 4% converted into scrub or grassland.

They also found that the number of patches of land had increased indicating fragmentation. In 1920 there were about 1,379 patches which kept steadily increasing over the years reaching a whopping number of 9,457 in 2015.

Threat to species

Previous studies have shown that the Eastern Ghats is home to more than 2,600 plant species and this habitat fragmentation and destruction can pose a serious threat to the endemic plants.

“We have sampling points across the four States where we regularly monitor the plants. When we carried out forest map overlay informatics analysis, we found fragmentation in areas where there are several rare, endangered, threatened and endemic species. Best suitable habitats for the plant species have decreased in the Eastern Ghats,” says Reshma M. Ramachandran, Ph.D. scholar at the Centre for Earth, Ocean and Atmospheric Sciences, University of Hyderabad and first author

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of the paper published in Ecological Indicators.

Habitat reduction mainly occurred in the districts of Gajapati (Odisha), Mahbubnagar (Telangana), and also in Nallamalai and Kolli hill ranges.

While agriculture was the main reason for deforestation during the early years, post 1975, mining and other developmental activities such as the construction of dams, roads were the culprits. In 1920, the mining area was only 622 sq.km, and in 2015 it had increased to 962 sq.km.

"The Eastern Ghats are often ignored. Even stakeholders are interested only in the Western Ghats and Himalayan studies. But they need to understand that the Eastern Ghats are also ecologically important. They play an important role in the monsoon break of both North-East and South-West Monsoon," says Dr. ParthSarathi Roy from Centre for Earth, Ocean and Atmospheric Sciences, University of Hyderabad. "There are also many tribal communities in this region and the government needs to shift its focus and fund more studies and monitoring programmes in this region."

Human–leopard conflict in the Himalaya

Human–animal conflict is common in the Himalaya like any other region where wildlife and people live together. A study of patterns of leopard attacks here reveal that some areas are high-risk zones requiring urgent conservation measures for the safety of both man and beast.

The foothills of the eastern Himalaya in northern West Bengal — called the dooars, a landscape comprising tea plantations and forests — alone have witnessed more than 700 leopard attacks on people between 1990 and 2016. In the western Himalaya (Pauri Garhwal in Uttarakhand), numerous leopards have been killed in retaliation to the human deaths and injuries they have caused.

Attack patterns

Scientists at the Wildlife Institute of India studied patterns of leopard attacks in both these regions. To list leopard attacks from 2000 to 2016, they accessed published literature, newspaper reports and data on monetary compensation awarded by forest departments. They visited 101 sites of attacks to confirm the details of incidents. On

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an average, leopards killed more than three and injured 11 people in Pauri each year between 2006 and 2016; in turn, 121 leopards met their ends at the hands of people. In the dooars, while 420 people were injured between 2011 and 2016 alone, there were barely any retaliatory killings.

The researchers find that around 97% of animal attacks in the dooars and 60% in Pauri resulted in human injuries. While a majority of the victims in Pauri were children and youth, middle-aged tea estate workers were most at risk in the dooars.

Despite this, 368 interviews with locals in both areas revealed that 41% of respondents in Pauri and 75 % in the dooars were positive towards the presence and conservation of leopards.

"The high percentage of positivism in the dooars is largely due to the strong foundation of Joint Forest Management activities that have long been practised here, leading to better awareness and participation of local communities in conservation," said S. Sathyakumar from Wildlife Institute of India, and coauthor of a study published in the journal PLOS ONE .

Predictive map

As part of the study, the team also used these data to develop a predictive risk map. This reveals that central and northern Pauri, as well as the protected and peripheral areas of central and south-western dooars are 'high risk zones'.

They suggest that immediate measures — including regular monitoring by wildlife managers and local response teams, providing proper lighting in villages and clearing bushes around houses — would be crucial to mitigate conflict.

ENVIRONMNT AND ECOLOGY

India home to two new gecko species

The spot-necked day gecko and the Anaimudi day gecko, both very distinctly-patterned lizards found only in the higher reaches of the Agasthyamalai and Anamalai hill ranges in the Western Ghats, are the latest additions to India's reptile fauna.

Researchers including Vivek Philip Cyriac of the Indian Institute of Science Education and Research Thiruvanathapuram (IISER-TVM) were surveying reptiles in Kerala's

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Shola National Parks in 2013 when they came across a predominantly greyish-brown-coloured gecko.

Red iris

The approximately six-centimetre-long lizard sported an unusual, bright red iris (a thin band surrounding the pupil of the eye) and a long, striking amber line also ran down its dark back: unlike anything the team had seen.

"We thought it could be a new species, but we had to make sure," said Cyriac.

So the team collected and studied the geckos' morphology in detail. The features they studied included the lengths of various body parts such as tail and fingers, lamellae (fine, plate-like structures on the base of gecko feet that help them scale vertical surfaces) and tubercles (tiny raised projections on their bodies). They compared these with the morphology of other similar-looking lizards to establish Cnemaspisanamudiensis or the Anaimudi day gecko, as a new species.

Spot-necked day gecko

The team (including scientists at the Zoological Survey of India and National Centre for Biological Sciences) utilized the same method to describe yet another day gecko they spotted at Kollam's Shendurney Wildlife Sanctuary – which is part of the Agasthyamalai hill range – in 2016. This gecko had bluish-white spots in a distinct 'necklace-pattern' on its nape. While this differentiated the species from the similar-looking Ponmudi day gecko and the Bedomme's day gecko, the lack of enlarged flat tubercles on its tail was one of the features that ruled out its possibility of being the ornate day gecko. The team named the new species Cnemaspismaculicolis or the spot-necked day gecko.

Both these diurnal geckos are currently known only from single localities in high-elevation forests located at more than 1,200 metres above mean sea level in the Ghats. There is a possibility that these day geckos could be present in the surrounding hills but more detailed surveys would be required to confirm this, said Cyriac.

While mountain ranges in general have a rather high diversity of such day geckos,

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the "accelerated environmental decline" that these regions face are a concern, he added.

Is Point Calimere Wildlife Sanctuary safe for migratory birds?

The water quality at the Point Calimere Wildlife Sanctuary might be unsafe for avifauna to feed and breed, notes a study that examined different pollution indicators in water. Researchers from Bharathidasan University, Tiruchirappalli compared their results with the Central Pollution Control Board (CPCB) and the United States Environmental Protection Agency (USEPA) standards to reach this conclusion.

The wildlife sanctuary located in Nagapattinam district of Tamil Nadu spreads across an area of 30 sq.km and comprises sandy coastal, saline swamps and thorn scrub forests around the backwater. Though it is a protected area and a Ramsar site, chemical companies and small-scale shrimp farms around the wetland have started to pose a threat to the biodiversity and ecosystem of the sanctuary.

A total of five sampling sites in the sanctuary were chosen for the study. Temperature of the atmosphere and water, and water quality analysis were carried out during the peak bird breeding season.

Atmospheric temperature at a few stations exceeded 36-40 degrees Celsius. "This can affect the egg albumen during the pre-incubation period, thereby providing better growth conditions for harmful microorganisms in the eggs," says the report published in Marine Pollution Bulletin.

The pH and salinity of the waters also exceeded the permissible limits for ecologically sensitive zones. Previous studies have shown that high acidic or high alkaline water can affect the metabolic and developmental activities of wild animals and birds.

"There are many salt pans near the sanctuary. This could be increasing the salinity. The chemical companies are also letting out untreated effluents into the waters. All this can have a deteriorating effect on the ecology," explains Rajendran Viji, research scholar at the university and first author of the paper. "Previously we used to see thousands of migratory birds, now the numbers have gone down to a few hundreds. The birds are starting to avoid the sanctuary."

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Microbial indicators such as coliform bacteria were also found to be very high at all the five sites. The faecal waste of the birds contains a high level of microbial load besides nitrogen, and this can significantly alter the nutrients in the water. Previous studies have shown that drinking the contaminated water can lead to deformities in birds. Coliform infections in the birds have also been reported to cause a change in their natural behaviour and even affect their long distance migration.

"There are also high chances for the prevalence of antibiotic resistance among the coliform bacteria and we are planning to do more investigation on this," says Lt. Dr. Shrinithivihahshini N.D, from the Department of Environmental Management at Bharathidasan University and coauthor of the paper. "Strict environmental regulations should be imposed and salt pan and other aquaculture practices around the sanctuary should be prohibited. Eco-tourism is also causing disturbances in this area."

Groundwater depletion alarming in northwest, central India

With 230 billion metre cube of groundwater drawn out each year for irrigating agriculture lands in India, many parts of the country are experiencing rapid depletion of groundwater. The total estimated groundwater depletion in India is in the range of 122–199 billion metre cube.

The Indo-Gangetic Plain, northwestern, central and western parts of India account for most intensive groundwater-based irrigation. And among these regions, western India and the Indo-Gangetic Plain have more than 90% of the area irrigated using groundwater.

Significant depletion

Based on Central Ground Water Board (CGWB) data of nearly 5,900 wells which have long-term data (1996–2016), a team of researchers led by Vimal Mishra from the Department of Civil Engineering at IIT Gandhinagar found that a majority of districts in India experienced significant depletion in groundwater storage. The satellite data confirms the well data. The results were published in American Geophysical Union's journal Earth's Future .

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While districts with significant decrease in groundwater are located in the Indo-Gangetic Plain, northwest, and central (Maharashtra) regions, a few districts in Punjab show substantial decline in groundwater table. With depletion occurring at a rate of 91 cm per year, Punjab has been witnessing a steep decline in groundwater table since 1996. “In northwestern India, the amount of groundwater extracted exceeds the total recharge leading to groundwater depletion,” says Prof. Mishra. In contrast, some districts in western India, east coast and peninsular India have witnessed an increase in groundwater levels.

“If groundwater is depleted and the region experiences drought for two–three years consecutively, there will be serious challenges. Availability of even drinking water will be a huge problem,” says Prof. Mishra. “Natural recharge during monsoon may not help much if groundwater depletion becomes acute, as rainfall of past several years controls the current groundwater storage levels.”

The study published in June this year found that groundwater recharge has declined between 1996 and 2016 in northwest and northcentral India due a reduction in low-intensity rainfall. Low-intensity rainfall during the monsoon is responsible for groundwater recharge in northwest and northcentral India. The study also found that carbon dioxide emission from pumping groundwater and release of carbon dioxide into the atmosphere from the soil when groundwater is depleted is less than 2-7% of the total carbon dioxide emissions in India.

Groundwater management

More than 500 tensiometers to visually monitor soil moisture conditions in rice fields and irrigate the crops only when required were used in five districts in Punjab. Irrigation based on information provided by the tensiometers helped farmers in the five districts save 10–36% groundwater. Using groundwater to irrigate the field only when necessary led to a reduction in electricity consumption and greenhouse emissions.

“The tensiometer gives visual information about the availability of soil moisture conditions. Irrigating the field based on this information will help conserve

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groundwater," says Prof. Kamal Vatta from the Columbia International Project Trust, New Delhi and co-author of the paper.

The tensiometer is 2–3 feet long and has a ceramic cup containing numerous tiny pores at the bottom. It is inserted up to 8 inches into the soil, which is beyond the root zone of rice. The water inside the tensiometer reaches equilibrium with soil moisture, and rises or falls depending on the amount of moisture in the soil.

"Farmers are advised not to irrigate the field when the water level in the tensiometer is in the green zone. When the soil gets dry the water level in the tensiometer drops and reaches the yellow zone in the device. Farmers should start irrigating the field at this time and never allow the water in the device to reach the red zone," Prof. Vatta explains.

According to Prof. Vatta, the instrument is quite accurate in monitoring soil moisture. One device per farm would be sufficient, especially when the terrain is nearly flat. So far, over 22,000 tensiometers, manufactured by Punjab Agriculture University, have been given to rice farmers in Punjab. It costs just Rs.300 per piece.

"Since stopping or reducing the subsidy in electricity prices may not be possible, farmers in the regions where groundwater depletion has already occurred should consider cultivating less water-intensive crops, use better irrigation technologies and irrigate crops only when necessary," says Prof. Mishra.

Now, fish included in praying mantid menu

Praying mantids prey on smaller insects and sometimes the odd frog or lizard. Now, it looks like they've added fish to their menu too, for naturalists have observed one catching and eating small ornamental fish in a garden in Bengaluru.

Guppy-catcher

It was on the evening of March 7 last year that naturalist Rajesh Puttaswamaiah's young son Arya came running to him at his home in Bengaluru, upset that "some spider-like insect" was catching his prized guppies. A curious Puttaswamaiah went to his first-floor terrace garden, where his large earthenware planter doubles as a mini-pond, replete with water lilies, water cabbage and small ornamental fish

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including guppies, zebrafish and molly fish.

What he saw was extremely intriguing: an almost six centimetre-large praying mantid of the species Hierodulatenuidentata was feasting on a freshly-caught guppy. A few hours later, Puttaswamaiah and his son observed the mantid catch yet another guppy.

They observed this for four more days: the mantid would appear at around dusk, fish guppies out of the water and promptly eat them. Over five days, it ate nine male guppies out of the 40 fish in the planter. Such fishing or fish-eating behaviour has never been recorded before in praying mantids, and Puttaswamaiah and his team reported it in the Journal of Orthoptera Researchrecently. “The mantid’s behaviour raises many questions,” says Puttaswamaiah.

Adaptations

The compound eyes of most mantids are adapted to daylight, but here was one that managed to hunt fast-moving prey – guppies – in very low light. Moreover, the insect was able to overcome the refraction of light in water (when light travels into water, it slows down, thereby changing direction slightly) which makes it difficult for a terrestrial predator to catch an aquatic creature.

Puttaswamaiah and his co-authors argue that the repeated predation also suggests that mantids could learn new hunting strategies from experience and different environmental cues.

However, while the observation is interesting, it would be safer to say that mantids have excellent vision and are now known to attack moving prey under water according to Divya Uma, a professor at the Azim Premji University who studies insects including mantids.

“Mantids attack any moving object of a particular size,” she wrote in an email. “Mantids (and all insects) can learn, remember and modify their behaviour based on experience. A strike towards a moving prey is an innate response.”

Tiger numbers on the rise

At a time when tiger deaths dominate national news, a new study offers hope for wild

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tiger populations across countries by showing that under optimal conditions, tiger numbers can triple in 18 sites across the world, including eight in India.

These are Anamalai-Vazhachal (in Tamil Nadu-Kerala), Sathyamangalam (Tamil Nadu), Balaghat (Madhya Pradesh), Achanakmar (Chattisgarh), western Rajaji and Nandhaur (Uttarakhand), Manas (across Assam-Bhutan) and Valmiki (across Bihar-Nepal). Currently, these regions support an estimated 62 tigers which could rise to 287 over the next 30-50 years: an increase of more than four times in India alone.

The study, published in PLOS ONE, was conducted by 49 conservationists of the World Wide Fund for Nature (WWF) across 10 tiger-range countries. They compiled the best available information — including the occurrence and abundances of tigers and their prey from available scientific studies, the connectivity of the protected areas and availability of protected buffer forests nearby as well as human disturbances including fragmentation through the Human Footprint Index. These were used for developing site-specific and ecologically realistic targets and timelines for the recovery of tiger populations in 18 tiger global “recovery sites”.

The results reveal that while the 10 tiger-range countries currently support 165 tigers, they could harbour 585 individuals. This rise could happen over 15-20 years in three sites including Uttarakhand’s Western Rajaji where natural prey is adequate, and over 30-50 years in the other areas where prey numbers would need to first recover.

While some tiger populations are already doing better (Manas, for instance, has over 30 tigers now), others such as western Rajaji are not, wrote lead author Abishek Harihar, a scientist with Panthera and NCF-India, in an email.

This new assessment could guide planning for tiger recovery globally and help inform more effective, integrated approaches to tiger conservation, he said.

Tackling growing incidents of human–tiger conflict in these areas would be crucial to aid this increase, according to the study. It also adds that the goal of doubling tiger numbers from about 3,200 to about 6,000 by 2022 may have been an “ambitious goal” that the signatories of the Global Tiger Recovery Program took on.

“As we move towards the [TX2] goal, we must recognise that global efforts put into

tiger recovery is aimed at the long-term survival of tigers in the wild, way beyond 2022," said Joseph Vattakaven, coordinating author and tiger biologist from WWF, India.

This study affirms the need for tiger-range governments to take a holistic, long-term view towards tiger recovery which must include plans for revival of prey animals and other wildlife at the site- level, said Dr. Rajesh Gopal, Secretary General of the Global Tiger Forum (an inter-governmental international body that works towards protecting tigers) in a press release.

The life of Andaman's sea kraits

The Andaman Islands are well-known for stunning beaches and now, the Sentinelese. Less-known are the colourful sea snakes – banded sea kraits – that also share these beaches. Now, a four-year study has helped shed more light on the mysterious terrestrial life of these amphibious snakes.

Banded sea kraits hunt for their prey in coral reefs. Though they spend a lot of time underwater, they have to get back to land to digest their prey, lay eggs and even slough their skin. Yet very little is known about their terrestrial lives for they are mostly nocturnal. To learn more, a team including researchers at the Andaman and Nicobar Environment Team led 27 volunteers on walks along the New Wandoor beach in the southern Andaman Islands to monitor the presence or activity of sea kraits between 2012 and 2016. The groups walked a 680-metre stretch between 6.30 and 9.30 p.m., 181 times and recorded the sea krait species they saw and what they were doing there.

The results, published in the Journal of Threatened Taxa, record both species of sea kraits on the islands: the yellow-lipped and the blue-lipped sea krait. They encountered 805 yellow-lipped sea kraits and 39 blue-lipped sea kraits on the surveys. The teams observed yellow-lipped sea kraits sloughing their skins on six occasions. They also observed pregnant females 37 times as well as brief courtship behaviour once. Another time, they also spotted a yellow-lipped sea krait resting in a hollow with an egg.

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Locations

Both species were mostly spotted on wood or tree roots (especially of uprootedManil karalittoralis, a mangrove tree) on the beaches where they were resting. The snakes also shared these tree-root crevices with hermit crabs. Sea kraits used the gradual slopes of sandy beaches to move from the sea to uprooted trees dispersed along the intertidal zone, suggesting that these beaches could be crucial for the snakes.

However, authorities removed the uprooted trees after the end of the study to "clear the beach for tourism purposes", note the authors. This could have "negative repercussions" for sea kraits, they add.

"The uprooted trees in the Andaman Islands provide a very unique environment which sea kraits have habituated themselves to," lead author Zoya Tyabji, currently with the Stellenbosch University in South Africa, said in an email.

Giving legal protection to sandy beaches and implementing the ban on certain activities (including sand mining and tourism) can help conserve neglected fauna, she added.

Are drugs discharged into the Yamuna toxic to aquatic life?

By studying nine different pharmaceutical active compounds in Yamuna river, researchers have now pointed out that it can "possibly cause chronic toxicity" to aquatic life and to humans who use this water for drinking purposes.

As our body does not use the entire quantity of the drug we take, most of it is excreted and end up in aquatic systems via domestic sewage. The report published in Ecotoxicology and Environmental Safety looks at the occurrence, fate and ecological risks of these compounds.

The researchers from IIT-Delhi and National Mission for Clean Ganga collected water samples from six sites across the 25 km river stretch during three different seasons (November 2010, April and July 2011).

Using different extraction processes, the pharmaceutical residues in the water were recovered and analysed.

The team looked at six over-the-counter drugs (aspirin, paracetamol, ibuprofen,

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ranitidine, caffeine, diclofenac) and three prescription drugs (carbamazepine, codeine, diazepam).

The highest concentration of pharmaceutical compounds was located downstream Wazirabad at the point where Najafgarh drain joins the Yamuna. This is one of the largest drains of Delhi and has an average discharge of about 25 cubic metres per second. The report notes that this drain is the largest polluter of the river contributing more than 50% of the total discharge into the Yamuna.

Ibuprofen and paracetamol

At this site, ibuprofen and paracetamol were found at a high concentration of 1.49 and 1.08 microgram per litre respectively. Previous studies have shown that even small concentration of ibuprofen could cause an antagonistic effect on aquatic organisms. Studies have also shown that ibuprofen exposure could increase cyanobacterial growth in the water.

Caffeine was found in high concentration in most of the sites. Caffeine is used as a stimulant in medicine; residue from beverages and other food products may be a contributor.

Even prescription drugs such as carbamazepine were found in the samples with the highest level at 1.35 microgram per litre.

After studying the hazard quotient, the researchers say that though the individual levels were small and cannot cause acute toxicity to the marine life, the mixture of compounds can cause chronic toxicity.

“We need more studies on the pharmaceutical residues as this is found to be an emerging problem in many countries. This not only affects the biodiversity of the river but can also lead to the rise of superbugs. Uncontrolled discharge of drug-containing effluents in our rivers and other water bodies can potentially make many microbes drug-resistant,” says Prof. Atul Mittal, one of the authors of the study. “Our sewage treatment plants are not designed to take care of these pharmaceutical compounds. Also, we have no guidelines or specific rules in place about this. We need to sensitize the government and this report is the first step toward it.”

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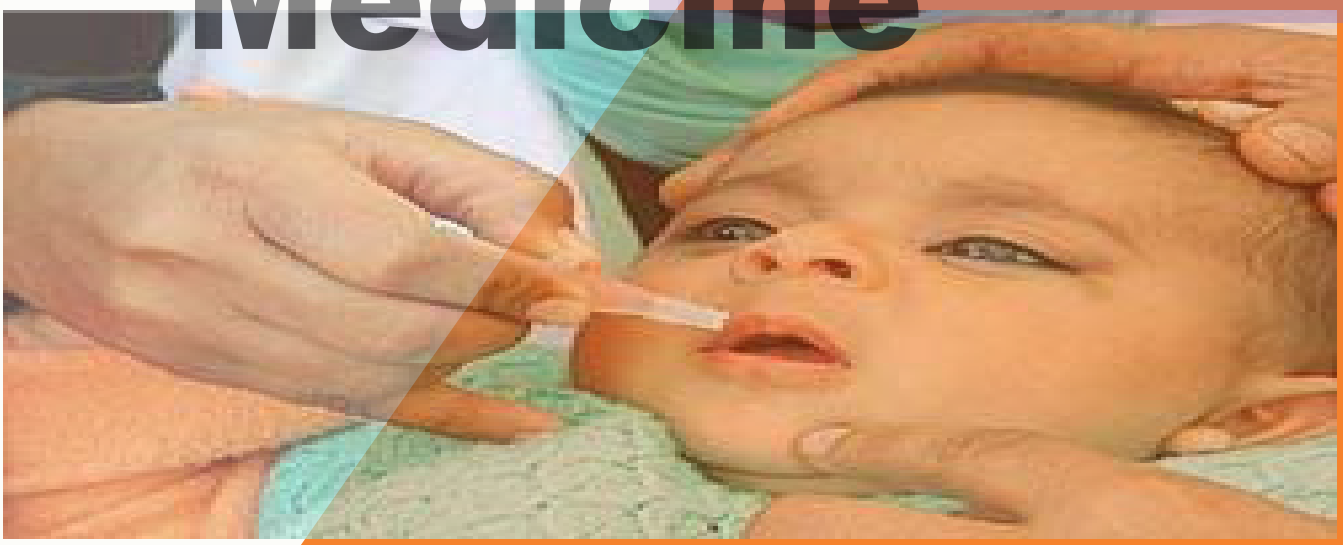

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Neurodegeneration to neuroregeneration: Exercise helps!

Over the last 30 years, the longevity of Indians, on average, has shot up remarkably. It was 41 years in the year 1960 and has risen to 68 years of age in 2015. While people live longer, age-related problems — both physical and mental — have become important issues to worry about and find solutions to. Progressive loss of memory and reduction in cognitive ability, together clubbed as dementia, has risen. It has been estimated that 4 million Indians suffer from some form of dementia. While Alzheimer's disease is one such neural disorder (1.6 millions of the 4 million), there are other disorders contributing to dementia too.

As we grow older, our brains change. The neural cells in the hippocampus, the part associated with learning, acquiring and maintaining memory, are damaged. If one were to find means of protecting this part of the brain and find ways to regenerate these neural cells, it should be possible to overcome and win over this problem and regain cognitive normalcy.

What are the factors leading to dementia? Some studies across the world had suggested that a 'risk gene' called APOE4, and another one termed presenilin might play some role here. But the frequency of APOE4 (and presenilin) is too low to be of major consequence (data from Dr. G. Chandak from CCMB Hyderabad and Dr. Mathuranath from Thiruvananthapuram), though there appears to be a regional variation across India (data from Dr. P.P. Singh of Punjabi University, Patiala).

A more important finding, and likely causative factor, comes from the imaging of the brain; this has found the hippocampus and some other parts of the brain to be tangled a bit, with some insoluble sheet-like 'plaques' which interfere with signal transmission in the brain. (Such a thing was first detected in what was called as the 'mad cow' disease detected in cows in U.K. which were fed meat products to eat). Yet others have suggested the role of a protein called brain-derived neurotropic factor or BDNF; when its level falls below optimum, dementia results.

Several methods have been tried to address the dementia problem. Attempts using vaccine candidates have not been successful, not attempts to use immune-therapy.

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Remarkably, sustained physical exercise seems to help — a remarkable connection between the physical and the mental. Exercise has long been thought of to stimulate neurogenesis, namely the generation of new nerve cells, just as it does muscular and cardiac cells. Towards this, a group led by Dr. Rudolph E. Tanzi at Harvard University in Cambridge, MA, USA has published a note in the September 7, 2018 issue the journal Science, using a mouse afflicted with Alzheimer's disease as the model.

How exercise helps

This group based its argument on the fact that the hippocampus in the brain contains neuro-progenitor cells which continue to generate new neurons. This well-known process is called Adult Hippocampal Neurogenesis or AHN. In Alzheimer's and other dementias, this process of making new neurons, namely, AHN, is impaired. The group argued whether AHN can be increased in the Alzheimer mouse by pushing the rodent to exercise on a running wheel for 3 hours every day for several days. (Why exercise? The reason behind this has been the claim that exercise is helpful for the body and the brain). They found several positive effects. (1) AHN was increased; more nerve cells were seen to be made; (2) the 'plaques' in the brain of the animal were reduced; (3) the levels of the molecule BDNF went up and (4) there was some improvement in memory. Thus, exercise in the demented mouse reduces pathology, increases neurons in the hippocampus and improves memory.

'Bottling exercise with chemicals' ?

The next question was: if exercise increases AHN through a rise in the BDNF levels and reduces pathology, why not replace exercise itself, and substitute it instead with biochemical treatment? To this end, they used methods to increase the levels of BDNF by injecting a drug molecule called AICAR (5-amino imidazole-4-carboxamide riboside), and another molecule called P7C3, which helps in the survival of new neurons. As Dr. Tara Spires-Jones and Dr. Craig Ritchie comment on the Harvard work in the same issue of Science, this paper provides clues about why exercise is good for memory. (They also add tongue-in-cheek that we could perhaps "bottle"

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the effects of exercise through vials of AICAR and P7C3! This may be appealing to those who cannot do physical exercise, and for the lazy ones, who do not want to!) Note, too, that the mouse was on the running wheel 3 hours per day for several days; in other words exercise should be sustained and continuous. Moral: It is thus a good idea for senior citizens to start and continue exercise early enough, say from their forties onwards. It is good for the overall body and the brain.

Does meditation help?

One issue that neither the Harvard paper nor its commentary makes any mention of is on the claim that meditation improves cognition, and is good against neuro-degenerative diseases. A paper by Dr Marciniak and others inFrontiers in Behavioural Neurosciences, 2014, (see the link https://doi.org/10.3389/fnbeh.2014.00017) has reviewed several studies relating to the meditation — cognitive improvement connection, and conclude that meditation could be a potentially suitable non-pharmacological intervention aimed at the prevention of cognitive decline in the elderly. However, given the limitations due to methods and differences in the various types of meditation used (Buddhist, Zen, Vihangya Yoga, Kirtan Kriya and others), they conclude that further research in this direction could help verify the validity of the findings and clarify the problematic aspects. Here again, sustained long- term meditation appears important and not a one-off type. Here is a set of experiments that some Indian neurosciences laboratories can work on, in order to obtain some molecular and cellular insights on the issue.

'Unethical to withhold bedaquiline while waiting for Phase III results'

In a recent Rapid Communication, the World Health Organisation (WHO) made important changes in the regimens to treat patients with multidrug-resistant TB (resistant to isoniazid and rifampicin). Two of the injectables (kanamycin and capreomycin) previously used for treating MDR-TB patients are to be replaced with a fully oral drug regimen. And bedaquiline drug, specifically developed for treating MDR-TB patients, has been included in the fully oral regimen. The injectables have been removed as they cause hearing loss (ototoxicity) and have increased risk of

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treatment failure and relapse. The changes in the MDR-TB regimen apply to both adults and children, though limited data are available for children. The new WHO guidelines for MDR-TB treatment will be released later this year.

Phase III trials

The new guidelines are not based on data from any Phase III trial of bedaquiline. In fact, no Phase III trial has been completed yet. WHO, therefore, relied on data of 50 studies and trials involving over 12,000 patients from 26 countries, including several countries where bedaquiline was used, to explore the safety and efficacy of the drug.

But in the absence of Phase III trial results, how was WHO convinced about the safety and efficacy of the drug? "WHO has recommended that all patients receiving newer drugs such as bedaquiline be closely monitored using dedicated and standardised active pharmcovigilance [monitoring the effects of drugs] measures. WHO has also established a global Active TB Drug Safety Monitoring and Management (aDSM) database to generate evidence on safety of MDR-TB regimens utilising the newer TB drugs," Karin Weyer, Coordinator, Diagnostics, Laboratories & Drug Resistance, Global TB Programme at WHO, Geneva said in an email. The data from this programme as well as safety data from observational studies and programmatic use of the drug in over 5,000 patients were analysed. "Results showed significant reductions in patient mortality while no new safety signals have emerged for both adults and children," she said.

"In contrast to the Phase IIb data, we have data of much larger number of patients and mortality is significantly lower in the bedaquiline group. This should reassure the sceptics," Soumya Swaminathan, Deputy Director-General (Programmes), WHO, Geneva said in an email.

The Phase IIb trial involving smaller number of MDR-TB patients showed that the drug was cardiotoxic and hepatotoxic (toxic to the liver) and seemed to cause more deaths. In June 2013, WHO published interim guidance for bedaquiline use,

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recommending its use in MDR-TB patients only when other treatment options were not possible. And in December 2012, the U.S. Food and Drug Administration granted accelerated approval to the drug for use in “serious or life-threatening conditions”. WHO again reviewed available evidence based on five studies at the end of 2015 and released a report in June 2016. The review showed a reduction in mortality in patients receiving bedaquiline, but there were unexplained serious adverse events of respiratory origin. Hence, the original WHO interim guidance was retained.

Against this background, why did WHO not wait for the Phase III trial results before revising its guidelines? “Part of the WHO core mandate is to ensure that MDR-TB patients have access to life-saving treatment. For bedaquiline, there is much more data available already (than for delamanid drug, for example) that it drastically cuts down on patients dying from disease and improves the chance for cure while not creating any new safety concerns. Given the complexity of MDR-TB treatment, the low cure rate currently reported globally for treatment success and the evidence from postmarketing surveillance, the use of bedaquiline (and other second-line medicines) is warranted in order to provide life-saving treatment to patients. Treatment can, therefore, not ethically be withheld while waiting for the phase III trial to be completed,” said Dr. Weyer.

No significant difference

According to her, the data for delamanid is much less definitive, despite the fact that a phase III clinical trial has been completed; Phase III trial using delamanid did not show any significant difference in curing the disease or reducing deaths thus belying the initial promise.

“Phase III trials are important because they strengthen the certainty in the evidence when reviewed by international practices such as GRADE [Grading of Recommendations Assessment, Development and Evaluation], which is also used by WHO for public health policy development,” Dr. Weyer said. “[But] trials are often mounted around specific research objectives and do not usually address all possible concerns that decision-makers may have. The WHO, therefore, uses the international

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GRADE method to formulate evidence-based policy recommendations."

The GRADE approach allows the findings from studies of different types to be summarised with a comprehensive assessment of certainty of their results based on standardised parameters. These findings are then collated into a formal recommendation, which often contains clearly specified conditions for implementation.

None of the second-line medicines for MDR-TB treatment are without adverse effects. But most of the adverse effects can be managed if detected rapidly, with the exception of ototoxicity (hearing loss), which is irreversible and associated with the injectable drugs. "This is why WHO is stressing the need for active drug safety monitoring and management as a core principle of clinical care in MDR-TB," Dr. Weyer stressed.

To make detailed information on clinical management of MDR-TB patients, including monitoring and managing drug adverse effects, WHO is currently updating the Companion Handbook. It will be released together with the upcoming new WHO guidelines.

Challenging the emperor of all maladies

Cancer is an uncontrolled growth and multiplication of cells in a given organ (for example, the lung or stomach), which are damaged due to inborn (genetic) or external triggers (such as smoking or high doses of radiation). While normal cells are programmed to multiply and grow to a certain size and stay so, cancer cells, whose DNA is mutated due to such damage, go on a rampant growth leading to tumours, weakening the body and ultimately even death.

Treating and winning over cancer has been a great challenge, and the oncologist-writer Siddartha Mukherjee has rightly named cancer as "The Emperor of all Maladies."

There have been a variety of approaches to win over this emperor. Surgical removal of the tumour has been one option, but it does not guarantee total removal (even a few leftover cells might grow again), nor its recurrence if the original cause is not

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addressed. Radiation therapy using high power gamma rays has also been tried, again with limited success.

Several anti-cancer drugs, such as cis-platin or carboplatin, 5-fluorouracil, doxyrubicin have been used. Many doctors have tried combining drugs along with shining the tumour using radiation such as gamma-rays for short periods of time. But the trouble is that they need to be used for sustained periods.

Immunological approach

It is here that immunological approach has been tried for a variety of cancers. This uses the in-built defense mechanism in the body. The white blood cells play a main role here. The B-Cells therein recognize the shape of the surface protrusion (call it the biometric ID) on the invading cell (be it a microbe or a cancer cell), synthesises proteins called immunoglobulins which fit into the surface of the invading cells and remove them. Importantly, this shape of the intruder's surface is "remembered" so that when a fresh attack by the same invader occurs, B cells are prepared. This too is the basis of childhood vaccines.

The surface geographic "tag" is termed the antigen and the proteins made by B-cells are called antibodies. Cancer cells also have biometric IDs, and these are termed neo-antigens. Anti-cancer vaccines are based on the principle of antibodies made against such neo-antigens. Antibodies such as bevacizumab and rituximab are some of the most popular drugs used against cancers. (The 'mab' at the end of these names refers to monoclonal antibody).

A recent approach in the field is to for the oncologist to isolate a piece of cancer tissue from the patient, and collaborate with a group of molecular bio-analysts to identify the neo-antigen on the cancer cells. Next, the oncologist asks an immunologist collaborator to prepare the specific antibody molecule, which can be injected to the patient so as to stop recurrence of the tumour. This is thus a therapeutic vaccine (not a preventive vaccine such as the one against hepatitis or mumps). Some such cancer vaccines are already in the market, for example, HER-2 against breast cancer, Revenge against cancer and T-VEC against melanoma.

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The Nobelists

It is here that this year's Nobelists have taken a different approach. They concentrated not on the B-lymphocytes but their partners, the T-cells. T cells release chemicals that push the invading cells to commit suicide (what is called apoptosis). Each T-cell has claw-like receptors on its surface that locks into antigens- foreign or abnormal. But the T-cell needs to be activated by certain proteins (called T-cell accelerators) before it triggers such a response. Additionally, there are also other proteins that help check the T-cell from going on a rampage. These proteins are called 'brakes' or "check point proteins".

Dr James Allison of the MD Anderson Cancer Centre at the University of Texas, Houston, TX, USA, has been working since the early 1990s on one such "brake" or "checkpoint "protein called CTLA-4, which down-regulates the immune response of T-cells. He wondered whether one could find a mechanism (or a protein) which can release this brake on CTLA-4. By 1994-95, his group produced a molecule called "anti-CTLA4", which, when injected on mice with cancer, unlocked the anti-tumour activity and cured the mouse of cancer. As the Nobel committee writes: "despite little interest from the pharmaceutical industry, Allison continued his intense efforts to develop this strategy into a therapy for humans. Promising results from emerged, and in 2010, an important clinical study showed striking effects in patients with advanced melanomas, a type of skin cancer. In several patients, signs of remaining cancer disappeared. Such remarkable results have never been seen before in this patient group".

This brings us to the work of the Nobel-sharer TasukuHonjo, currently at Kyoto University, Japan. He discovered, even before Allison, in 1992, that a protein called PD-1 is expressed on the surface of T-cells. His continuing work on it showed that it too is a checkpoint protein; if it were released, T-cells can exhibit anti-tumour activity. Towards this, he developed the antibody Anti-PD1, which when introduced for the treatment of patients with different types of cancer, the results were dramatic.

The trick in both instances, Allison's or Honjo's, is to find molecules that will release

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the brake or the checkpoint, and let the anti-cancer activity occur. As one would expect, research in to checkpoint inhibitors is booming. As a columnist writes: “more than 1100 PD-1 related trials are under way; immunotherapy is now the hottest field in oncology and one that is likely, over the next five to ten years, to transform the way that many cancers are treated”.

With the advances made by the Allison’s and Honjo’s groups, it does appear that the Emperor’s reign may indeed come to an end sooner than later.

Existing drug can be used for treating gallbladder cancer

By sequencing the whole exome of 44 early-stage gallbladder cancer samples taken from patients, researchers at Tata Memorial Centre, Mumbai, have been able to identify the mutations that cause the cancer. More importantly, based on the genomic analysis, the team has made it possible for clinicians to know in advance which gallbladder cancer patients are likely to benefit from a particular therapy that is currently being used for treating colorectal cancer.

Though rare globally, there is high incidence of gallbladder cancer in India and China. Yet, there are almost no treatment options available. This is now set to change.

A team led by Dr. Amit Dutt from the Integrated Cancer Genomics Laboratory at ACTREC, TMC found that in about 40% of samples sequenced, a particular signalling pathway (ErbB/HER) was significantly altered either by mutation or by having multiple gene copies. Changes in the gene copy number in the ErbB family of receptor pathway are responsible for causing colorectal cancer too.

The ERbB pathway belongs to the EGFR family. And in the case of gallbladder cancer, the ErbB2 binds to EGFR to activate the pathway. So the anti-EGFR therapy currently being used for treating colorectal cancer can potentially be used in gallbladder patients to stop the growth of cancer. Based on studies carried out in the laboratory, it is likely that the drug will inhibit the spread of gallbladder cancer. This becomes particularly important as gallbladder cancer is an aggressive disease — it spreads (metastasis) rapidly and the five-year survival rate is only about 20%.

“Based on genomic analysis we found that not all patients with ErbB2 mutation

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will benefit from the anti-EGFR therapy. That is because patients having a specific mutation in the KRAS gene (another member of the ErbB/HER pathway) that co-occurs with the ErbB2 mutation will not respond to the drug," says Dr. Dutt. The results of the study were published in the International Journal of Cancer.

KRAS mutations

The KRAS mutations are of two types — G13D and G12V. "The G12V mutation is the strongest activating mutation. So patients who have this [G12V] mutation will not respond to the anti-EGFR therapy, while those who have the G13D mutation will partially respond to treatment," he says. And patients with G13D mutation are sixfold more likely to respond to treatment compared with G12V mutation. Patients who do not have any of the two KRAS mutations will 100% respond to the therapy.

The researchers validated the ability of the drug to treat gallbladder cancer using a mouse model. Tumours were induced in mice by transplanting human gallbladder cancer cells. Three sets of cancer cells were transplanted. In one, cancer cells with only the ErbB2 mutation were transplanted. The second set of mice received cancer cells with ErbB2 mutation and G13D mutation. The third set of mice received cancer cells with ErbB2 mutation and G12V mutation. The drug was administered orally.

All the mice with only the ErbB2 mutation were successfully treated, while a few with ErbB2 mutations and G13D were treated. However, mice with ErbB2 and G12V mutations did not respond to treatment.

"For every gallbladder cancer patient, molecular profiling (which was not done till now) can be done to know whether the patient has KRAS mutation and if so whether it is the one that partially responds to treatment [G13D] or the one which does not [G12V]," Dr. Dutt says.

This approach will help clinicians take an informed decision to specifically identify patients who are more likely to benefit from the anti-EGFR therapy.

"So we can potentially save patients with G12V KRAS mutation from the toxic effect of chemotherapy drug," Dr. Dutt says.

"The study gives a potential new target in precision medicine. It forms a basis to

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evaluate the drug in patients through clinical trials. And if the trial is successful then we can make it a standard of care," says Dr. Shailesh V. Shrikhande from the Department of Gastrointestinal and Hepato-Pancreato-Biliary Surgical Oncology, TMC and one of the two first authors of the paper.

NCCS' approach makes bone marrow transplantation more successful

One of the reasons why the efficiency of bone marrow transplantation gets compromised is due to fewer hematopoietic stem cells available for transplantation. Researchers from the Pune-based National Centre for Cell Science (NCCS) have addressed this by using a novel way to multiply or expand the number of hematopoietic stem cells before transplantation. Importantly, the procedure also improves the body's ability to accept the transplanted stem cells and begin producing new blood cells (engraftment potential). Increase in the engraftment potential improves the success rate of bone marrow transplantation.

A team led by Dr. Vaijayanti Kale from NCCS had earlier found that treating hematopoietic stem cells with nitric oxide improved the engraftment potential of juvenile cells. However, adult hematopoietic stem cells lost the engraftment potential when treated with a nitric oxide. "So in the latest study we treated the mesenchymal stem cells with a nitric oxide-producing compound (a nitric oxide donor)," says Dr. Kale.

The nitric oxide donor-treated mesenchymal stem cells (MSCs) secreted micro-vesicles that were enriched in certain factors have the ability to increase the engraftment potential of hematopoietic stem cells. "Micro-vesicles are normally secreted by all cells. But the micro-vesicles secreted by MSCs treated with the nitric oxide donor are rich in two mRNAs — Jagged-1 and VEGF-A," says SapanaJalnapurkar from NCCS and first author of a paper published in the journal Stem Cells. There was about 200-fold increase in Jagged-1-specific mRNA and about 7-fold increase in VEGF-A-specific mRNA in these micro-vesicles.

Micro-vesicles secreted by naïve mesenchymal stem cells do not show such high expression of Jagged-1 or VEGF-A-specific mRNAs.

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The micro-vesicles enriched with these two mRNAs were cultured with hematopoietic stem cells for three days. There was an increase in the number (expansion) of hematopoietic stem cells at the end of three days of culture. Two signalling pathways involving Jagged-1 and VEGF-A were also induced when the micro-vesicles entered the hematopoietic stem cells. The pathway involving Jagged-1 plays an important role in self-renewal or multiplication of the stem cells whereas the pathway involving VEGF-A is required for HSCs to reach the bone marrow (homing) and be retained there.

After culturing with micro-vesicles, the hematopoietic stem cells were infused into mice that had undergone whole body irradiation to kill the stem cells in the bone marrow. “We found that the infused stem cells reached the bone marrow (homing) and produced new blood cells (engrafted). Compared with controls, there was 30-40% increase in the engraftment of hematopoietic stem cells. This is quite significant,” says Dr. Kale.

After four weeks, the peripheral blood contained 50-55% of blood cells that were derived from the donor stem cells; it was 40% after 16 weeks. In the case of bone marrow, the engraftment of HSCs was 30% after 16 weeks. “This is 5-6-fold more engraftment compared with control,” Dr. Kale says.

To test the engraftment efficiency, the researchers extracted the cells from the bone marrow of mice 16 weeks after receiving the donor stem cell infusion. The HSCs were separated and then infused into another set of mice that had undergone whole body irradiation. Blood cells in the peripheral blood after four and 16 weeks of infusion were 40% and 20-25% respectively. In the case of bone marrow, the stem cell engraftment was 7% after 16 weeks; the control mice had only about 1% engraftment. “There is 6-fold more engraftment in the bone marrow of the secondary mice, which is significant,” Dr. Kale says.

“Nitric oxide-donors are already being used as drugs for certain cardiac conditions. Similarly, mesenchymal stem cells are already in clinical use. So it will be relatively straight forward to use them in clinical settings to vastly improve engraftment and

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achieve greater bone marrow transplantation success. This finding has an important application in transplantation done with gene-edited hematopoietic stem cells," says Dr. Kale.

AIIMS-led team develops sensitive tests for pulmonary, pleural TB

A highly sensitive diagnostic test for pulmonary TB and pleural TB has been developed by a multi-institutional team led by Jaya Sivaswami Tyagi from the Department of Biotechnology at AIIMS. The diagnostic test makes use of a DNA aptamer (a small single-stranded DNA molecule that binds to a specific target molecule) that shows high binding affinity to a TB antigen. Sputum samples were used for diagnosing pulmonary TB while pleural fluid was used for diagnosing pleural TB.

The sensitivity of the diagnostic test for pulmonary TB and pleural TB was 94% and 93%, respectively. Specificity was 100% for pulmonary TB and 98% for pleural TB. The results were published in the journals ACS Infectious Diseasesand Analytical Biochemistry.

The laboratory-based aptamer test for diagnosing pulmonary TB takes about five hours to turn in the results while the portable, rapid test takes just 30 minutes. "The lab-based test has several steps and so takes time while the rapid test is an electrochemical sensor-based detection which is a direct detection and so takes less time," says Surabhi Lavania from AIIMS and first author of the pulmonary TB paper and coauthor of the other paper. At 92.3% and 91.2%, the sensitivity and specificity of the portable test is a bit inferior compared with the lab-based test.

In the case of pleural TB, the aptamer-based lab diagnosis was far superior to even Xpert. While the sensitivity was about 22% with Xpert, it was about 93% with aptamer. "Xpert relies on the presence of bacteria, which is nearly absent in pleural fluid, while the aptamer-based testing relies on bacterial antigen and so has high sensitivity," says Pooja Kumari from AIIMS and first author of the paper on pleural TB test.

The sensitivity of the lab-based and portable aptamer-based test for pulmonary TB is far superior compared with smear microscopy, X-ray and even ELISA.

Cost-effective

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'The portable test is cheaper and can be used for screening pulmonary TB and active case finding in high-risk groups," says Prof. Tyagi.

The HspX antigen present in sputum samples of people with pulmonary TB is made use of for diagnosis. The team had used the same antigen present in the cerebrospinal fluid samples for diagnosing TB meningitis (published in September 2018 in Tuberculosis). The researchers made use of a particular aptamer (H63SL2-M6) that detects the antigen in sputum samples for pulmonary TB diagnosis.

"Sputum is a difficult sample to handle due to the presence of mucus. The sputum should first be made into a uniform suspension before applying the test. So [we] must prepare the sample and this takes time," says Prof. Tyagi.

In the case of the lab-based diagnosis, the sputum sample is immobilised on a plate and the aptamer is added. If the sample is positive for pulmonary TB then it will contain the HspX antigen and the aptamer binds to it. An enzyme (horseradish peroxidise) that binds to the aptamer (through biotin-streptavidin affinity) is then added followed by a substrate. A change in substrate colour is seen indicating that the sample is positive for pulmonary TB. If the sample is negative for pulmonary TB, then even the first step of the aptamer binding to the sample does not take place and the colour change does not occur.

Relying on HspX antigen to diagnose pleural TB in a lab setting was found be effective and highly sensitive (93%).

Rapid diagnosis

To make the pulmonary TB diagnosis portable, the researchers bound the aptamer to an electrode coated with gold nanoparticles. "When the sample containing the HspX antigen is added, the aptamer binds to the antigen and undergoes a structural change, which is read out in the electrical signal," says Dr. Tarun Kumar Sharma from Translational Health Science and Technology Institute (THSTI), Faridabad, and the other corresponding author of the papers. "There is a drop in electrical signal if the sample is positive and no change in signal when the sample is negative."

The electrode is already immobilised with the aptamer, so only the liquefied sputum

has to be added and the reaction is instantaneous. “Most time is taken to liquefy the sputum sample than the testing per se,” says Prof. Tyagi. No sample processing is needed in the case of pleural TB samples.

“We are also trying to adapt this aptamer on an electrode for rapid diagnosis of pleural TB,” says Dr. Sharma.

“We have applied for a patent for the aptamer reagent and have licensed it to AptaBharat Innovation Pvt. Ltd, a start-up at THSTI. We soon plan to validate the tests on well characterised panel of specimens and field evaluation,” says Prof. Tyagi.

International Commission questions the studies on cancer induction by cell phone radiation

With the phenomenal growth in the number of users of mobile phones worldwide, there is public concern that cell phone radiation may cause adverse health effects such as brain cancer. Recently, the US National Technology Program (NTP) and the Ramazzini Institute published their animal studies on the cancer-inducing potential of cell phone radiation. Though the former is yet to publish its conclusions, interested parties interpreted the studies wrongly. On September 4, 2018, the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the agency whose recommendations most nations and agencies, such as the WHO, accept published an eight-page report questioning the usefulness of these reports and asserting that both these studies have inconsistencies and limitations. The very expensive, $25 million NTP study did not provide any input for revising the currently recommended radiofrequency guidelines.

Weight of evidence

The NTP researchers used weight of evidence approach, whereby potential effects were described as being supported by ‘clear’, ‘some’, ‘equivocal’ or ‘no’ evidence (where a study was not adequate for comment on potential effects, it is described as an ‘inadequate study’).

The researchers did not find any ‘clear’ evidence in their studies; the strongest

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evidence of carcinogenicity reported was ('some evidence') for male Hsd: Sprague Dawley SD rats exposed at different specific absorption rates (SAR) of (electromagnetic radiation) energy. They found that the exposure-response relation to be statistically significant.

Falcioni et al reported a significant increased incidence of schwannomas (a type of tumour) in the hearts of male rats exposed at the highest SAR (0.1 W/kg) of mobile phone radiation, which according to them is consistent with one of the NTP studies. They also reported increased incidence of heart Schwann cell hyperplasia — proliferation of apparently normal cells — (male and female) and malignant glial tumours (female only), but these were not statistically significant.

Limitations

The ICNIRP noted that both studies followed good laboratory practice (GLP); both used much larger numbers of animals than previous research, and both exposed animals over the whole of their lives. However, the Commission noted that "in determining the relevance of the results for human exposure guidelines, potential limitations need to be carefully considered, and whether any of the evidence regarding health effects in rodents is sufficiently strong and relevant to humans to serve as a basis for exposure guidelines".

ICNIRP criticised the studies on many grounds, including methodological deficiencies.

"For cancers which have benign tumour precursors, progression to cancer often involves a sequence from hyperplasias (proliferation of apparently normal cells), to dysplasia (cell abnormalities present), to cancer (a small percentage of these cells undergo malignant transformation)" ICNIRP explained.

Quoting appropriate literature, ICNIRP observed that for schwannomas, less than 30% of hyperplasias progress to malignancy..., thus many more benign hyperplasias should be observed than malignant schwannomas.

"The NTP study found approximately equal numbers of hyperplasias and malignant schwannomas, which is a large departure from the expected ratio of many hyperplasias

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to very few malignancies. These results suggest that for radiofrequency fields to be carcinogenic, they would need to affect the conversion rate from hyperplasias to malignancies in addition to potentially inducing hyperplasias. However, with very few cases with cardiac Schwann cell hyperplasia and schwannomas (for example, none in the control group), it is difficult to interpret and accept this finding without further clarification," ICNIRP argued. The Commission noted that Falcioni et al also did not report the expected conversion rate.

The Commission asserted that it saw two mutually inconsistent sets of results, and no similar literature for comparison.

The agency found that the distribution of malignant cardiac schwannomas across the experimental groups in the two studies also reduces confidence in the data.

"ICNIRP considers that the NTP (2018a, b) and Falcioni et al (2018) studies do not provide a consistent, reliable and generalizable body of evidence that can be used as a basis for revising current human exposure guidelines," the Commission concluded. It may not amuse many activists and scaremongers!

Multiple reasons behind premature births in India

A recent study that analysed nearly 8,000 women in India who gave birth between 2004 and 2005 and 2011 and 2012 (India Human Development Survey) has pointed out that there is a strong association between adverse birth outcomes and sanitation access, gender-based harassment and physical labour.

About 14.9% and 15.5% of the study group experienced preterm birth and low infant birth weight respectively. The researchers found that spending more than two hours per day fetching water was associated with low birth weight while open defecation or sharing latrine within the building was associated with greater chances of low birth weight or preterm birth. The paper was published in PLOS ONE.

"Many homes in low-income countries have no private toilet facilities and private drinking water source. Women and girls are tasked with fetching water from outside the home, which can be physically stressful," says Prof. Kelly Baker, from the Department of Occupational and Environmental Health, University of Iowa College

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of Public Health, U.S in a release. She is the corresponding author of the paper. “In addition, homes often lack private toilet facilities, meaning women must use shared or public latrines or manage their sanitation needs in open spaces,” she says.

Harassment

Another shocking find of the study was that harassment of women and girls in the community was also associated with both preterm birth and low infant birth weight. “Interventions that reduce domestic responsibilities related to water and sanitation and changed social norms related to gender-based harassment may reduce rates of preterm birth and low infant birth weight in India,” adds the report.

Though there were limitations due to self-reported behaviours and small sample size, the study was able contribute to the limited evidence related to sanitation infrastructure and other social factors that play a role in preterm birth and low infant birth weight.

How progesterone protects breast cancer patients unravelled

Researchers from Mumbai-based ACTREC-Tata Memorial Centre (TMC) have uncovered the biological mechanism by which a single injection of progesterone administered prior to surgery benefits breast cancer patients immaterial of whether progesterone receptors are present or not. Progesterone treatment prior to surgery reduces the chances of migration and invasion ability of primary cancer cells to other parts of the body thus reducing the possibility of a relapse.

A large clinical trial carried out by Dr. Rajendra Badwe and colleagues in 2011 at TMC found progesterone treatment prior to surgery produced beneficial effects in breast cancer patients independent of the progesterone receptor status. The results were published in the Journal of Clinical Oncology. The mechanism behind this which was not known then has now been deciphered by a team led by Dr. Amit Dutt from the Integrated Cancer Genomics Laboratory at ACTREC, TMC. The results of the study were published in the Journal of Biological Chemistry.

While the beneficial effects of progesterone were seen in the trial, the researchers did not know how women who did not have the receptors for the hormone too

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benefited. The team set to unravel this. They treated breast cancer cell lines with progesterone and looked for changes in gene expression. They found two genes (SGK1 and NDRG1) were significantly produced in abundance (overexpressed) in cells treated with the hormone.

They looked at the same cells for changes in microRNAs and found the expression of a few microRNAs was reduced in response to the hormone treatment. “Of these, two microRNAs which were down regulated [decrease the quantity of protein produced] also regulate the expression of SGK1 gene,” says Dr. Dutt. “The normal function of the two microRNAs is to reduce the amount of SGK1 enzyme produced. So when the microRNAs are down regulated, the amount of SGK1 enzyme produced increases.”

Progesterone action

The team found that progesterone treatment acts in two ways — it directly increases the amount of SGK1 enzyme produced and also causes the two microRNAs to increase the amount SGK1 produced. “SGK1 is targeted by both progesterone hormone and by the two microRNAs in response to the hormone. There is a dual-phase regulation of SGK1,” says Dr. Mukul Godbole from TMC and first author of the latest paper.

“SGK1 gets over expressed by the hormone in the case of women who have receptors for progesterone. But in women who don’t have the receptors, the progesterone reduces the expression of microRNAs leading to increased expression of SGK1,” explains Dr. Godbole. “This is how, immaterial of whether women have progesterone receptors or not, the hormone treatment prior to surgery reduces the chances of migration and invasion of cancer cells and the possibility of a relapse.”

Studies done by other researchers had suggested that another set of genes (AP-1) regulate the expression of the NDRG1 gene. Since AP-1 genes are stress genes, it was suggestive that stress might be responsible for increased production of the NDRG1 enzyme. In this case, progesterone treatment stresses breast cancer cells and this causes the NDRG1 enzyme levels to increase. A previous study of primary

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tumour before and after progesterone treatment hinted at the possibility of the hormone stressing the cancer cells causing the NDRG1 levels to be elevated in the tumour. The results of this study by researchers at TMC and NIBMG, Kalyani, were published in Breast Cancer Research and Treatment.“The breast cancer cell lines we studied were mimicking what was happening in the primary tumour,” says Dr. Dutt.

While the three genes (SGK1, NDRG1 and AP-1) play a role, the way the three genes are linked was not known. Using a genetic approach the team found that if any of the three genes was removed (knocked out) the progesterone that was added did not arrest the migration or invasion ability of cancer cells. Likewise, when any of the three genes was introduced or over expressed it resulted in significant reduction in the spread of cancer cells even in the absence of progesterone.

Since progesterone is a female hormone, it cannot be given to men and children. “But with the understanding of the molecular mechanism we can use drugs to target SGK1 or NDRG1 and increase its levels without administering progesterone hormone,” says Dr. Dutt. This becomes particularly important as the beneficial effects of progesterone on other solid tumours such as lung and pancreatic cancer can possibly be modulated by using drug molecules that behave as surrogates of the hormone.

Mother’s milk, microbiome influence rotavirus infection in babies

By studying the complex interplay between the sugars and microbes in mother’s milk and the baby’s gut microbes, an international team of researchers has tried to understand neonatal rotavirus infection.

Rotavirus infection is one of the leading causes of gastroenteritis in children under five years worldwide. Babies in 10 Indian states are immunised against rotavirus.

Monkey kidney cells

The researchers first investigated whether human milk oligosaccharides (specific sugars in milk) can inhibit infection by a particular strain (G10P11) of rotavirus. In vitro studies were carried out on monkey kidney epithelial cells (MA104 cells).

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Though mother's milk sugars should be ideally killing the virus, the researchers found that the oligosaccharides enhanced the infection of cells with this strain of rotavirus.

"We found that specific human milk oligosaccharides also improved the replication of the vaccine [used in the immunisationprogramme in India] in vitro . At this point, we don't have a clear understanding of the mechanism by which this happens...It is possible that the oligosaccharides confer some kind of structural stability to the virus and improve the efficiency of uptake by cells," explains Dr. Sasirekha Ramani from Baylor College of Medicine in Houston, U.S., in an email. She is the first author of the paper published inNature Communications.

This enhanced viral replication could further boost the immune response of the baby against the virus, which could mean better protection for the infant.

Validation

The researchers then repeated the study in a neonatal nursery to validate their lab results. A study group of 181 mother–infant pairs were selected from the Christian Medical College (CMC), Vellore. The sugars and microbiome of breast milk, and baby's gut microbiome were characterised.

They found that oligosaccharides responsible for increased infectivity were "significantly higher" in breast milk where the babies had symptomatic infection. There were also specific differences in the milk microbiome.

"An association between oligosaccharides profile of milk, microbiome of milk and rotavirus infection in babies has been found. At this point, our understanding of the mechanisms by which the milk microbiome impact neonatal rotavirus infection is very preliminary. We need field studies to understand the impact of these results in the context of vaccine response and immunity," adds Dr. Ramani.

"Why neonatal rotavirus infections are neonatal is a question that has fascinated me. While we have not yet answered that question, we have advanced our understanding of factors that influence rotavirus infection, particularly the role of breast milk. Understanding multiple aspects of breast milk — microbiome and its

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composition including sugars — is critical for us to think about how to improve breast milk quality and its beneficial impact on children," Prof. Gagandeep Kang, now at the Translational Health Science and Technology Institute, Faridabad, and previously at CMC, Vellore says in an email.

New markers to monitor TB treatment

Besides treatment, there is an urgent need for monitoring tuberculosis treatment to achieve better results. Researchers from the National Jalma Institute for Leprosy and Other Mycobacterial Diseases, have succeeded in identifying a couple of cell-based markers to study the response of TB patients to treatment.

Currently, studying the sputum of the patient using microscope is the only tool for treatment monitoring. "Sometimes patients can't produce sputum, especially children and elderly patients. And when the patient is undergoing treatment also, he does not produce enough sputum. The microscopy method has low sensitivity - it needs atleast 10,000 bacilli/mL to detect properly," explains Dr. Sonali Agrawal, who completed her PhD from the Institute. She is the first author of the study published in Frontiers in Immunology.

The researchers collected blood samples from about 15 individuals, who were newly diagnosed with pulmonary TB and studied the expression of immune cell associated markers - T regulatory markers and Th17 associated markers.

Flow cytometry

The expression of cell-associated markers was studied by flow cytometry. This technique involves adding specific antibodies against cell-associated markers of interest. These antibodies carry specific fluorophores (or fluorescent tags) which when excited by laser emits fluorescence. The number of cells that carries a specific marker and multiple cell-associated markers can be detected by the flow cytometer.

The individuals were undergoing anti-TB treatment for new smear-positive pulmonary TB (referred to as category I patients) and these markers were analysed again after two, four and six months. They found a significant decrease in the expression of CD25 marker and the subset of T regulatory cells (CD4+CD25+) and this decline

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was gradual as the treatment continued.

The authors note that these cells can act as better markers for monitoring the treatment efficacy. Though previous studies have shown an association between T- regulatory cells and Mycobacterium load, this is the first study to establish the link in TB treatment by monitoring at different time points.

"This is pilot study and needs movalidation. We are planning to carry out studies in a larger cohort," says Dr. Madhan Kumar, Scientist from the Department of Immunology at the institute and corresponding author of the paper. "We are also working on developing a panel of more immune specific markers and take the test to the field, which may also help in predicting failure cases if studied on those lines. We observed that a subset of T regulatory cells, CD4+CD25+FoxP3 declined in patients who had resolved cavitary lesions by chest X-rays by the end of treatment. Thus this marker could also be useful in predicting favourable response in patients with extensive lung lesions".

Mutations that influence bipolar disorder, schizophrenia identified

By sequencing the exome (the part of the genome composed of exons that gets translated into proteins) of 32 people from eight families who suffer from mental illness such as bipolar disorder, schizophrenia and psychosis, Bengaluru-based researchers have identified 42 rare mutations in the genes implicated in very severe mental disorders.

Heritability

Mental illnesses such as bipolar disorder, schizophrenia and psychosis have nearly 80% chances of heritability, which indicates a genetic component. However, variations in a single gene cannot account for the manifestation of the disease. "So we adopted an approach to maximise the potential to identify the genetic components that influence the disease. This we did by studying the members of the same family who have the disease," says Dr. Odity Mukherjee from Institute for Stem Cell Biology and Regenerative Medicine (inStem), Bengaluru and corresponding author of a paper published in the journalPsychiatry and Clinical Neurosciences.

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Three-step process

The variants were identified through a three-step process — the variant should cause significant perturbation to the gene, should be shared across affected members within a family, and should not be present in healthy control. Eight healthy people from five of the eight families and 25 individuals who have no history of severe mental illnesses were used as controls.

Not all the 32 people with mental illness had all the 42 variants. Each family has its own set of unique variants shared among its affected members, while also having more common variants shared across families that somehow cause similar kind of disorder, the researchers found.

“We have identified variations in the genes which we believe influences the clinical outcomes. But we are yet to understand how these variations influence the clinical outcomes,” Dr. Mukherjee says.

“The interesting part of our study is that the variants we identified are in genes that cause severe neurological disease or aberrant brain development. The variants [mutations] that cause neurological disease or aberrant brain development are not in exactly the same location in the gene that causes syndromes such as spinocerebellar ataxia and Cornelia de Lange syndrome,” says Dr. Sanjeev Jain from the Department of Psychiatry at the National Institute of Mental Health and Neurosciences (NIMHANS), Bengaluru and co-author of the paper.

Complexity unravelled

The fact that the identified variations overlap with genes involved in both brain development, and brain degeneration, and also in genes that have been identified in other data sets suggests that the complexity of these diseases can be slowly, but surely, unravelled, says Dr. Jain.

“We identify variants in genes hitherto not reported in the context of severe mental illness, but that could potentially contribute to disease biology,” the authors write in the paper.

The researchers are planning to use induced pluripotent stem cell lines from these

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families and brain cells in vitro to understand how the variants affect the working of the brain cells. “This will help us understand how the genetic variants though different in each family cause similar kind of illnesses,” says Dr. Jain.

How our brain enables us to rapidly focus attention

Scientists have discovered a key mechanism in the brain that may underlie our ability to rapidly focus attention.

Our brains are continuously bombarded with information from the senses, yet our level of vigilance to such input varies, allowing us to selectively focus on one conversation and not another, according to the study published in the journal Neuron.

However, this mechanism is not well understood.

Research has shown that the electrical activity of the neocortex of the brain changes, when we focus our attention. Neurons stop signalling in sync with one another and start firing out of sync.

It is known that the cholinergic system in the brain plays an important role in triggering this desynchronisation. The cholinergic system consists of clusters of special neurons that synthesise and release a signalling molecule called acetylcholine, said Stephen Williams from the University of Queensland in Australia, and these clusters make far-reaching connections throughout the brain.

Not only does this cholinergic system act like a master switch, but mounting evidence suggests it also enables the brain to identify which sensory input is the most salient — worthy of attention — at any given moment and then shine a spotlight on that input.

“The cholinergic system broadcasts to the brain, ‘this thing is really important to be vigilant to’,” said Prof. Williams.

Williams and researcher Lee Fletcher wondered if layer 5 B-pyramidal neurons, the ‘output’ neurons of the neocortex, might be involved, because they are intimately involved in how we perceive the world.

“The output neurons of the neocortex perform computations that are thought to

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underlie our perception of the world," said Williams.

The researchers wanted to know if the cholinergic system is able to influence the activity of these output neurons.

Using a technique called optogenetics, they modified neurons in the cholinergic system in the brains of mice so that they could be activated with a flash of blue light, triggering a sudden release of acetylcholine.

This allowed the researchers to closely monitor the interaction between the cholinergic system and the output neurons. They discovered that if the output neurons were not currently active, not much happened. However, when those neurons received excitatory input to their dendrites, the cholinergic system was able to massively increase their activity.

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JNCASR restores memory in mice with Alzheimer's

Using a small molecule that activates two enzymes (CBP/p300 histone acetyltransferases), researchers from India and France have been able to completely recover long-term memory in mice with Alzheimer's disease. Neuron-to-neuron connections that form the network were re-established leading to memory recovery in the diseased mice. The therapeutic molecule used in the study was synthesised by a team led by Tapas Kundu from the Molecular Biology and Genetics Unit at Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru.

The small molecule was found to activate the two enzymes, and the two enzymes by virtue of being the master regulators activate several genes that are important for memory. In a June 2013 paper in the Journal of Neuroscience, Prof. Kundu's team had demonstrated the small molecule's ability to generate new neurons and induce long-term memory in normal mice.

Memory in mice

"If it is able to induce memory in normal mice, we wondered if it can induce and recover lost memory in mice with Alzheimer's," recalls Prof. Kundu. "We found the molecule activating the two enzymes in the diseased mice and producing new neurons. Also, 81 genes whose expression was repressed in mice with Alzheimer's were activated to normal levels." Besides completely recovering lost memory, other symptoms of Alzheimer's such as balance problem was also addressed.

The amyloid plaques and neurofibrillary tangles contribute to the degradation of the neurons leading to memory loss in Alzheimer's. "The plaques and tangles absorb these two enzymes. So once the enzymes are activated by the small molecule, the whole process of neurodegeneration gets reversed," he says.

Most clinical studies of Alzheimer's have failed as cognitive dysfunction associated with the disease emerges quite late when the brain is affected by the deposition of plagues and tangles, and cell death. The possibility of reversing the damage

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through production of new neurons and connection between neurons therefore offers promise. “There is a possibility that the small molecule may at least be able to delay the cognitive decline and improve the conditions of patients,” he says.

“We didn’t see the plaques and tangles progressing and growing. Don’t think they get destroyed. We need to carry out more studies to confirm the fate of plaques and tangles,” he says.

Blood-brain barrier

Since the small molecule cannot cross the blood–brain barrier and enter the brain, the researchers turned to carbon nanospheres synthesised by a team led by Prof. Muthusamy Eswaramoorthy, Chemistry and Physics of Materials Unit at JNCASR and coauthor of the latest paper published in the journal EMBO Molecular Medicine .

The carbon nanospheres, about 400 nanometres in size, are synthesised using glucose, and the small molecule is attached to the surface of the nanospehere.

“As reported in a 2008 paper in the journal Nano Letters, glucose easily crosses the blood-brain barrier. So it acts as a vehicle to ferry the molecule into the brain. Since the nanospheres retain some glucose property they are able to ferry the molecule and reach the brain in about 48 hours,” says Prof. Eswaramoorthy.

“We were able to see high concentration of the molecules in the brain in 48–72 hours after administering,” says Prof. Kundu, who is currently the director of Central Drug Research Institute (CDRI), Lucknow.

The nanospheres were not seen after 21 days, probably because the glucose was consumed by the brain.

The study tested the ability of the small molecule in recovering memory at an early stage of disease onset. “Currently, we are studying mice with Alzheimer’s disease that are one year old. And the initial results are promising,” he says.

Synthesis of the small molecule and carbon nanospheres and testing them on normal mice were carried out in JNCASR, while testing them on diseased mice model was done in France.

Prof. Kundu is looking at the prospect of founding a start-up company to carry out

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toxicity studies.

DNA tool to assess disease risk from genome analysis

Scientists say they have developed a new DNA tool that uses machine learning to accurately predict people's height and assess their risk for serious illnesses such as heart disease and cancer.

The tool, or algorithm, builds predictors for human traits such as height, bone density and even the level of education a person might achieve, purely based on one's genome, according to the research published in the journal Genetics.

"While we have validated this tool for these three outcomes, we can now apply this method to predict other complex traits related to health risks such as heart disease, diabetes and breast cancer," said Stephen Hsu from Michigan State University (MSU) in the U.S.

Further applications have the potential to dramatically advance the practice of precision health, which allows physicians to intervene as early as possible, researchers said.

The research analysed the complete genetic makeup of nearly 500,000 adults in the U.K. using machine learning.

The computer accurately predicted everyone's height within roughly an inch.

While bone density and educational attainment predictors were not as precise, they were accurate enough to identify outlying individuals who were at risk of having very low bone density associated with osteoporosis or were at risk of struggling in school.

BIO-TECHNOLOGY

IIT Guwahati fabricates superior scaffold for cartilage repair

Implanting cartilage alone or injecting cells found in healthy cartilage (chondrocytes) at the site of injury to heal the damaged cartilage in patients with osteoarthritis does not produce favourable results. Similarly, implanting two different scaffolds joined together to simultaneously regenerate the cartilage and reconstruct the bone too has many limitations.

The problem arises because the interface between the cartilage and bone scaffolds,

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which are made of different materials, is not connected but has a distinct boundary. As a result, the interface tends to delaminate and degrade. Now, researchers from Indian Institute of Technology (IIT) Guwahati have addressed this shortcoming by fabricating a silk scaffold where the junction between the cartilage and bone scaffold is continuous and seamless and hence less prone to damage under load-bearing environment of the joint.

A team led by Biman B. Mandal from the Department of Biosciences and Bioengineering has fabricated the biphasic scaffold where the top portion is highly porous and spongy thus mimicking the cartilage, while the bottom portion is reinforced with silk fibre thus imparting more stiffness and less porous to mimic the bone. Since the entire scaffold is made of silk, the interface merges with one another and is seamless despite having different porosities and stiffness. The results of the study were published in the Journal of Materials Chemistry B.

The researchers made scaffolds using both wild silkworm (Antheraea assamensis) and mulberry silk (Bombyx mori) and found scaffolds made of non-mulberry silk were superior to the one made of mulberry silk in all respects.

“To make the biphasic scaffold we prepared silk solution by completely dissolving the silk. We then added chopped silk fibres to the solution so the bottom half portion of the scaffold becomes fibre-reinforced silk composite while the rest of the top portion had only the silk solution,” says Prof. Mandal. The solution is processed by reducing the temperature to –20 degree C and then vacuum dried to remove water. The top portion of the scaffold is highly porous and soft like a sponge whereas the bottom portion is less porous and strong. The biphasic scaffold was treated with alcohol to make it water-insoluble.

The porosity is intended for neighbouring cells to migrate, infiltrate and regenerate in the scaffold, and support better nutrient exchange. The less porous silk-reinforced scaffold portion allows bone cells to optimally grow. Owing to the RGD sequence in the non-mulberry silk, more cells tend to migrate to the scaffold and proliferate.

Seeding stem cells

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"It is also possible to take a patient's bone marrow stem cells and seed them on the scaffold. The stem cells will differentiate to become mature cartilage-like and bone-like cells. Our scaffold is amenable to stem cell seeding and differentiation protocols," Prof. Mandal says.

Validation of the scaffold that was seeded with cartilage and bone cells was first done through in vitro studies. "We saw elevated levels of cell proliferation, extra-cellular matrix deposition and higher tissue-specific gene expression within the construct. These proved that the construct was compatible and good," says Yogendra Pratap Singh from IIT Guwahati and first author of the paper. "The cartilage cells prefer a softer matrix compared to bone cells and our construct was suitable for both types of cells to proliferate."

The compatibility and ability of the scaffold to regenerate cartilage and bone was then tested in rabbits. The scaffolds were studied eight weeks after implantation. "The fibre-reinforced scaffold allowed more bone formation, while regeneration and complete repair of the cartilage was seen," says Singh, who currently is a Newton-Bhabha Fellow at the University of Sheffield. "We found the non-mulberry silk scaffold outperformed the mulberry silk one."

The researchers found the non-mulberry silk scaffold had 1.5 and 0.5 times more bone and cartilage cells respectively attached than in the mulberry silk scaffold. Gene expression was nearly double in the non-mulberry silk scaffold than in the mulberry silk scaffold. Also, the extra-cellular matrix in both the cartilage and bone portion of the scaffold increased six-fold in 14 days.

The fibre-reinforced scaffold mimicking the bone was 10 times stronger than the sponge-like portion. Greater compressive and tensile strength of fibre-reinforced scaffold are desirable.

The researchers are planning to test the scaffold on larger animals, preferably pigs.

BIO-TECHNOLOGY

Bacteria to degrade toluene

Using bacteria isolated from soil and effluents near an oil refinery, researchers

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from the University of Delhi and Indian Institute of Technology (BHU), Varanasi, have successfully degraded toluene into less-toxic byproducts. Toluene is one of the petrochemical wastes that get released without treatment from industries such as refineries, paint, textile, paper and rubber. Toluene has been reported to cause serious health problems to aquatic life, and studies point that it has genotoxic and carcinogenic effects on human beings.

To the soil and effluent samples containing some bacteria 100 mg/L of toluene was added and incubated for four weeks. The bacteria were isolated from the samples, identified and studied for their toluene-degrading abilities. They isolated eight to 10 strains of bacteria and found that a particular bacteriaAcinetobacter junii showed good degrading potential — about 80% of toluene (50 ppm) in a liquid medium was degraded within 72 hours.

"A consortium of A. junii bacteria was found to be more effective than using a single strain. Different bacterial strains have different characteristic potential to degrade intermediate by-products formed during the degradation process and, hence, increase the efficiency," says Pardeep Singh from the Department of Environmental Studies at PGDAV College, University of Delhi and the first author of the paper published in Energy, Ecology and Environment.

Another interesting find was that when exposed to toluene, these bacteria changed their morphology to escape toxicity. Electron microscopy studies revealed that the cylindrical cells transformed into an ovoid or spherical structure. The researchers also examined the pathway by which the bacteria were doing the degradation and found it to be general aerobic biodegradation pathway. "The bacteria use up this toluene as their carbon source in the presence of oxygen. Though most of the waste degradation studies have involved the use of bacteria that grow in an anaerobic environment, we tried an aerobic one and succeeded," he adds.

The researchers also tested the bacterial strain for the degradation of benzene, phenol, and xylene and they showed effective results towards degradation of these compounds — both individual compounds and their mixtures. In laboratory conditions,

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the bacteria were able to degrade these petrochemical wastes in both soil and water samples. More studies are needed to design industrial-scale bioreactors for taking up large-scale degradation of petrochemical waste.

IIT Guwahati uses aloe vera to remove oil from water

Researchers have for the first time used a naturally occurring material — aloe vera gel — which inherently has superior oil repelling (oleophobic) property to separate oil from water. So far researchers have only been mimicking the structure of naturally existing materials such as fish scales to achieve super oleophobicity. While conventionally the topography and chemistry of materials had to optimised to make them repel oil extremely, the use of aloe vera gel–based coating modified with some molecules was sufficient to make the surface of substrates extremely oil repelling.

Aloe leaves

The team led by Dr. Uttam Manna from the Department of Chemistry at Indian Institute of Technology (IIT) Guwahati used the thick gel contained in the leaves of aloe vera plant to convert a commercially available porous material that is oil-loving (oleophilic) to become extremely oil-repelling by coating it with the gel.

Like a drop of water that nearly retains its spherical shape when placed on a lotus leaf, the commercially available material coated with the gel exhibited high oil contact angle of about 150 degrees under water. The greater the oleophobic nature of a surface the higher will be the contact angle and more spherical will be the shape of the oil droplet.

The researchers found the gel by itself had superior oleophobicity with contact angle of 156 degree. Even when subjected to extreme conditions such as exposure to boiling (100 degree C) water for 60 minutes and liquid nitrogen (–196 degree C) for 24 hours the oleophobic nature of the gel was not compromised. Similarly, the oleophobicity of the gel remained intact when exposed to various chemically harsh conditions such as very acidic (pH 1) and highly alkaline (pH 12) medium, artificial sea water and river water for 30 days.

Super-oleophobic

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"We were surprised seeing the gel exhibit super-oleophobicity. But even more surprising was that the gel retained super-oleophobicity even after we exposed it to several harsh conditions," says Arpita Shome from IIT Guwahati and first author of a paper published in the Journal of Materials Chemistry A.

The researchers used the gel to coat a commercially available porous material that is inherently oleophilic (oil-loving). Once coated, the material became extremely oil-repelling with contact angle of 151 degrees. The super-oleophobicity remained intact even when exposed to severe chemical conditions (highly acidic and alkaline water, artificial sea water and river water) but reduced a bit (146 degrees) when subjected to bending and twisting. But the oleophobicity reduced drastically to less than 100 degrees under severe physical abrasions such as sand paper abrasion, knife scratching test etc.

The team directed its efforts to make the surface exhibit super-oleophobicity even after extreme physical abuse. For that they used a small molecule (dipentaerythritol pentaacrylate or 5Acl) to bind to the coated gel. "About 99% of the gel is made of water, and amino acids and enzymes among other things make up the remaining 1%. The amino acids and enzymes provide amine group which helps in binding (cross linkage) with the small molecule," says Dr. Manna.

Post binding with the small molecule, the oleophobicity reduced to 138 degrees. "We increased the oleophobicity to 155 degrees by adding glucamine, which is hydrophilic, to the coating," Dr. Manna says. The oil-repelling nature remained intact even when the material was stretched by 150% and bent for about 1,000 times.

Being porous and stretchable, the coated material acts a membrane to separate oil and water. Since it is super-oleophobic (and therefore highly water-loving), the membrane allows water to pass through it thus helping in separating oil from water.

The researchers were able to separate both light (kerosene) and heavy oil from water using the membrane. "We were able to use the membrane repeatedly for at least 25 times to separate oil from water and the efficiency of separation remained

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above 97%," Dr. Manna says. The membrane retained its efficiency to separate oil and water even under harsh conditions of extreme pH, high salinity, and low and high temperatures.

IIT Roorkee team uses tamarind seed protein to treat chikungunya

Researchers have found that a protein found in tamarind seeds reduces the infectivity of chikungunya virus by 64% and the virus RNA levels inside infected cells by nearly 45%. Based on the promising results obtained through in vitro studies, the researchers are planning to test the protein on animals to prevent and/or treat chikungunya infection. Currently, there are no drugs to treat chikungunya or any vaccine to prevent it.

The study published in the journal Virology has for the first time confirmed that the sugar moiety on the surface of alphaviruses has a role in infectivity; this is known for other viruses such as HIV and influenza.

Virus compromised

The team led by Shailly Tomar from the Department of Biotechnology at the Indian Institute of Technology (IIT) Roorkee found the tamarind protein (tamarind chitinase-like lectin or TCLL) binds to the sugar moiety (N-acetylglucosamine or NAG) present on the surface of chikungunya virus. When TCLL protein binds to the NAG sugar moiety it nearly coats the virus particles thus preventing the virus from binding with the receptors on the host cells. Since binding to the host cell receptors, which is the first step in the infection process, is nearly prevented, the ability of the virus to infect the host cells is compromised.

Based on structural studies carried out by Pravindra Kumar's team at IIT Roorkee it became clear that the TCLL protein specifically binds to NAG sugar molecules. "Since tamarind seeds are traditionally used in Ayurveda to treat many ailments and conditions, we wanted to know the molecules in the seed. Two proteins were found in abundance. Based on amino acid sequence, we found one protein has both anticoagulant and blood thinning properties while TCLL, which is a lectin protein, binds specifically to NAG sugar molecules," says Prof. Kumar, who is a coauthor of

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the paper.

"We wanted to study if TCLL binds to chikungunya virus through the NAG moiety. Our hypothesis was that if the TCLL protein binds to NAG, the virus will not be able to attach and interact with host cell receptors leading to less infection," Prof. Tomar says.

The team first demonstrated the ability of the TCLL protein to bind to the NAG sugar moiety found on chikungunya and Sindbis virus, which too belongs to the alphavirus genus.

Binding of TCLL to chikungunya virus through the NAG sugar moiety was then confirmed by first treating the protein with the NAG molecule and then incubating the NAG-treated protein with the virus. "We found that the NAG molecule binds to the TCLL protein and prevents the protein from binding to the virus," Prof. Tomar says. "This helped confirm that TCLL binds to chikungunya virus through NAG."

They found that chikungunya virus treated with the TCLL protein showed nearly 64% reduction in the ability to infect host cells. But in the case of NAG-treated TCLL, the reduction in chikungunya virus infectivity was just 14%. "Like antibodies that bind to the virus surface and neutralises or prevents the virus from binding to the host cells, the TCLL protein binds to NAG and prevents the virus from interacting and infecting the host cells," she says.

TCLL protein of different doses was incubated with the virus for different time periods. They found that 100 micromolar of the protein incubated with the virus for just 30 minutes was sufficient to cause 64% drop in infectivity.

Explaining why only 64% reduction in infectivity was seen when the virus was treated with the protein, Ramanjit Kaur from IIT Roorkee and first author of the paper explains: "Besides NAG, there could be other sugar molecules through which the virus interacts with the host cells. Also, there may be other receptors on the host cells which allow the virus to get into the cells."

The antiviral effect of the protein was also assessed by measuring the RNA levels inside the infected cells. Treatment of the virus with TCLL led to a reduction of 45%

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chikungunya RNA levels inside the host cells.

"The TCLL protein can bind to glycan found on nearly 30 members of the alphavirus genus. So the finding of this study has huge implications," Prof. Tomar says. Based on the findings of this work, Prof. Tomar and Prof. Kumar have filed a patent for chikungunya antiviral composition consisting of TCLL protein.

Novel strategy to treat diabetic wound infection

By using virus that infects bacteria (bacteriophages), researchers from Panjab University have successfully treated multidrug-resistant bacterial infection in diabetic mouse model. People with diabetes are more prone to fungal and bacterial infections and the emergence of multidrug-resistant organisms has worsened the situation. Researchers have been searching for alternative treatment approaches such as phytochemicals, metal ions, antibacterial nanoparticles, antibacterial enzymes. The phage therapy has shown promising results among various alternative treatments studied.

Phage therapy

"Phage therapy or use of a specific virus to target particular bacteria was in use in many countries before the popularisation of antibiotics. Even now it is used in Russia, Georgia, Poland and other countries. Though it is currently not used in India, it is an option we should choose as there is an increase in the number of drug-resistant pathogens in our country," explains Prof. Sanjay Chhibber from the Department of Microbiology, Panjab University and first author of the paper published in Frontiers in Microbiology.

In order to protect the phage and help in its slow release into the body, the researchers encapsulated the phage in a natural lipid casing called liposome. The liposome entrapped phage was injected into diabetic female mice to treat methicillin resistant Staphylococcus aureus -infected wound and the healing was studied for 20 days.

The healing was studied in four different groups of mice. One was not given phage or clarithromycin, one was given phage cocktail but not encapsulated, other was

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given liposome-loaded cocktail of bacteriophages and the last was treated with clarithromycin only.

The group treated with the liposome-entrapped phage showed a significant decrease in the wound size on day five itself and complete closure of wound was seen by day nine. The study showed liposome-loaded phage eradicated bacterial infection in 10 days whereas untreated mice showed high bacterial burden.

The researchers also studied the inflammatory markers (myeloperoxidase) produced by neutrophils at the wound site. These are the first cells that reach the site of infection or inflammation. So studying neutrophils or its markers is suggestive of the level of inflammation or bacterial load. The level was lowest in the liposome entrapped phage-treated group, which indicated the clearance of bacterial infection. This group also showed maximum deposition of mature collagen tissues at the site of the wound by day five, thus aiding in rapid wound healing.

“Phage therapy can be used as a personalised therapy where the patient is first tested for bacterial infection and then treated with the appropriate phage. Also, it is very effective compared with antibiotics as it requires only a single dose, and its concentration does not decrease as long as it has the bacterial host,” he adds. “Phages are very safe and non-toxic. They are in our system, we encounter them each day in our food and water. Phages have no effect on humans as their host is bacteria, not us.”

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High intestinal parasite levels in bonnet macaques

Bonnet macaques living near people have more intestinal parasites than those living in forests, shows a study recently published in PLOS ONE. So monkeying around by relocating such commensal macaques could spread parasites to wild macaques and other forest species, suggest scientists.

Just like big cats or jumbos, monkeys too are sometimes relocated to forests from human-dominated areas. Yet does this measure — aimed at reducing human–wildlife conflict — hold dangers?

Instances of relocation

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To find out, researchers from Coimbatore's Bharathiar University and Sálim Ali Centre for Ornithology and Natural History first compiled information on instances of primate relocation in India and found that of the 25 relocations between 1998 and 2017 (none of which attempted to relocate the entire group or screen the monkeys for diseases or endoparasite infections), 13 were of bonnet macaques across south India.

Focusing on bonnet macaques and their gastrointestinal parasites (endoparasites, which can be transmitted to other macaques in the vicinity through faeces or water), the team followed 20 macaque troops across Karnataka, Tamil Nadu and Kerala in 2014-15 and collected 161 macaque poop samples to study parasites levels. For comparison, they also followed macaques in the forests of Karnataka's Sirsi–Honnavara between 2015 and 2016 and collected 205 poop samples. They quantified parasite eggs and cysts in these samples.

They found as many as 24 endoparasites (19 taxa of helminths or worms and five taxa of protozoans) in both urban (commensal monkeys living near humans) and forest macaques. Almost all macaque groups had at least one endoparasite in them. They found that the amount of food that an urban macaque group availed from human-dominated areas determined the number of endoparasite taxa and levels of endoparasites in them. Macaque groups that accessed such food from dumps and other areas had more species of endoparasites. Immature macaques had the highest levels of endoparasites. Endoparasite levels across seasons revealed that the parasites persisted in the monkeys every month. The species richness of endoparasites was highest in summer.

Parasite transfer

Relocating such infected monkeys to the wild as part of conflict mitigation measures could transfer new parasites into wild populations in the area, write the authors. Just like in people, higher parasite loads in animals can affect physiological functions. This could make their survival in the wild difficult, said co-author of the study Palanisamy Sundararaj, assistant professor at the Bharathiar University.

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"Macaques should be screened for parasites before relocation," he added.

IIT researchers 3D bioprint load-bearing bones

Researchers from Indian Institute of Technology (IIT) Delhi and IIT Kanpur have used a different approach to mimic the development biology pathway by which adult load-bearing, long bones are formed. The bone construct was fabricated by combining tissue engineering and 3D bioprinting. The study also helped in understanding the detailed gene expression and sequential signaling pathways that get upregulated when embryonic-stage cartilage becomes bone-like cells.

How bones form

There are two ways in which bones are formed. In the case of cranial bones (which are not load-bearing), mesenchymal stem cells directly differentiate into bones without being converted into a cartilage. However, in the case of load-bearing, long bones, such as femur, stem cells first form a cartilage template, which then undergoes further differentiation to form bone cells. Bones formed from a cartilage template are designed to bear weight.

Till date, all attempts to develop load-bearing bones using different scaffolds have been by differentiating the stem cells directly into bone cells thus bypassing the crucial, intermediate stage of cartilage formation. "The efficacy of such bone constructs is yet to be demonstrated in bearing loads. There is very poor correlation between bone constructs developed in vitro and in vivo . Also, gene expression pattern of these tissue-engineered bones largely differ from human adult bone," says Prof. Sourabh Ghosh from the Department of Textile Technology at IIT Delhi and one of the corresponding authors of a paper published in the journal ACS Biomaterials Science & Engineering.

In a paper published last year in the journal Bioprinting, the same team used 3D bioprinting and bioink (which contains silk proteins, mesenchymal stem cells and growth factors) to tissue engineer the cartilage.

In the latest work, the cartilage was first 3D bioprinted using bioink and cartilage characteristics were thoroughly characterised. The researchers then added a thyroid

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hormone (Triiodothyronine or T3) to the cartilage to facilitate the differentiation of cartilage into bone-like cells.

Stark difference

Unlike bone cells formed directly from stem cells, bones formed through cartilage differentiation in the lab exhibited a stark difference — gene and protein expressions were similar to when bone development occurs naturally in the body.

Also, the three key cellular signaling pathways for osteogenic differentiation were found to be upregulated. “When we followed a different strategy to develop bone there is more similarity to limb skeleton development in vivo,” says Prof. Ghosh.

“The load-bearing capacity of a bone depends primarily on the quality of extracellular matrix. In loading-bearing bones, the extra cellular matrix comprises 95% while bone cells are just 5%. So if you are trying to fabricate a load-bearing bone construct it is better to have more extracellular matrix,” says Prof. Amitabha Bandyopadhyay from the Department of Biological Sciences and Bioengineering at IIT Kanpur and another corresponding author of the latest paper. “Compared to bone formed directly from stem cells, the extracellular matrix of the bone construct developed through the intermediate cartilage process was 10s of times higher.”

“We followed a four-step process to develop the load-bearing bone. We first developed chondrocytes (cartilage) from stem cells and then differentiated them into hypertrophic chondrocytes. During this process, the sponge-like cartilage becomes a brittle tissue. While the brittleness is not good for cartilage, here it is following the development biology mechanism to become a bone,” says Prof. Ghosh. In the third step, the hypertrophic chondrocytes differentiate into bone-like cells (osteoblasts) and finally to adult bone cells (osteocytes).

While it takes three weeks for the cartilage to be formed from mesenchymel stem cells (chondrogenesis), it takes another two weeks for bone formation (osteogenesis).

Though the paper does not report on mechanical properties of the bone construct, Prof. Ghosh says mechanical studies carried out show better results than when the bone has been developed directly from stem cells. The team plans to undertake

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studies on animals.

IISER Pune develops new model of evolution of bacterial colonies

Researchers from Indian Institute of Science Education and Research (IISER) Pune propose a change in the way epidemiologists estimate the growth and adaptation rate of bacteria. The paper, to be published in Evolutionary Biology, poses this challenge to both theoreticians and experimentalists who are studying the growth of asexual populations subject to periodic bottlenecks.

Bacteria enter the body of a host organism and multiply into billions. But the population is not steadily growing within the body. There are periodic instances, known as bottlenecks, when they are purged in huge numbers. This could be, for example, when the host sneezes or defecates. On these occasions the bacteria gets into the body of a second host and spreads there. So the number of bacteria in the first host decreases considerably at the time of bottlenecks. In performing calculations, it is of interest to know which number to take as the estimate of population size of the bacteria, as this will also decide how they grow and proliferate. This size is related to and directly affects the extent or rate of adaptation, which is a measure of how much a trait has changed compared to the ancestor. The rate or extent of adaptation is ultimately the quantity that researchers seek to estimate or measure.

Harmonic mean

A longstanding assumption made by researchers is that a quantity called the harmonic mean decides the rate of adaptation of the bacteria. The harmonic mean is the product of the population size at the bottleneck (NO) and the number of generations between two successive bottlenecks (g). However, there has been no empirical or theoretical test for the validity of the harmonic mean as a predictor of the extent of adaptation.

“As a starting point, we performed experiments on E. coli populations to test if the harmonic mean of population size (NOg) can predict extent of adaptation. Our experiments revealed that this does not hold,” says Sutirth Dey of IISER Pune who is an author of the paper.

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Knowing the extent of adaptation is of interest, both theoretically and practically. When epidemiologists estimate the way a disease spreads, they frequently have to make predictions about the rate at which various types of bacteria will evolve under different conditions.

The researchers then simulated the growth of asexual populations (those that multiply via fission) using their proposed model and found g, the number of generations between bottlenecks, to have a complex relationship with the rate of adaptation. While it partly enhances the extent of adaptation, they also obtained the counter-intuitive result that higher values of g decreased the extent of adaptation. This is counter-intuitive, because when there are more generations between two bottlenecks, it would appear that there are more fissions, and hence a greater scope for variation and adaptation. Because of this they propose in this paper that rather than using NOg , the factor NO/g where gvaries inversely should be used to calculate extent of adaptation.

“We have not yet provided an analytical proof for this – we are working on it. Meanwhile this result is an invitation for theoreticians and experimentalists to re-examine some fundamental assumptions about how bacteria evolve,” says Dr Dey.

Now, graphene can detect brain disorders

Graphene, a form of carbon and a super-strong, ultra-light material discovered in 2004, enables flexible electronic components, enhances solar cell capacity, and promises to revolutionise batteries. Now scientists have added one more use to this list.

Detecting ALS

They have found a potential new application of this material for detecting Amyotrophic Lateral Sclerosis (ALS) — a progressive brain disorder for which there is currently “no objective diagnostic test.” This is described in the journalApplied Materials & Interfaces of the American Chemical Society.

ALS is characterised by rapid loss of motor neurons controlling skeletal muscles,

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leading to paralysis.

"We have a new exciting work on the application of graphene that may one day be used to test for ALS and other neurodegenerative diseases", co–first author Bijentimala Keisham, a PhD candidate working under Vikas Berry, Associate Professor of Chemical Engineering at the University of Illinois in Chicago (UIC), told this correspondent in an email.

Graphene consists of a single layer of carbon atoms arranged in a hexagonal lattice, each atom bound to its neighbours by chemical bonds. The elasticity of these bonds produces resonant vibrations known as phonons.

Graphene's use to detect ALS exploits its ability to change these resonant vibrations in a very specific and quantifiable way when an extraneous molecule is introduced into the lattice, says the report. The foreign molecule affects the vibrational energies of graphene and the changes can be "accurately mapped using Raman spectroscopy", a technique commonly used in chemistry to provide a structural fingerprint by which molecules can be identified.

In their study the UIC team found a distinct change in the vibrational characteristics of graphene when Cerebro-Spinal Fluid (CSF) — found in the brain and the spinal cord — from patients with ALS was added to it. The researchers carried out the test using the CSF from 13 people with ALS; three people with multiple sclerosis (MS) and three people with an unknown neurodegenerative disease.

Three changes

"The changes in graphene's phonon vibration–energies, as measured by Raman spectroscopy, were unique and distinct," Keisham said. "These distinct changes accurately predicted what kind of patient the CSF came from — one with ALS, MS or no neurodegenerative disease."

The authors, however, add this strategy does not analyse the Raman signal of the CSF but rather "looks at the change in the Raman signal from interfaced graphene".

"In summary, we demonstrate a robust system to investigate ALS by using graphene,"

says the report. “The results suggest that our graphene platform can be used not only to potentially diagnose ALS, but also to monitor its progression,” it says.

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NCCR develops system to estimate, predict flooding within Chennai

In 2015, unprecedented and sudden floods paralysed Chennai with over 18 lakh people being displaced. Following this, at the behest of the office of the Principal Scientific Advisor to government of India, research institutions, chief among them the National Centre for Coastal Research (NCCR), Chennai, and IITs, got together to build a flood warning system customised for use in Chennai. Carrying the acronym C-FLOWS, which stands for Chennai FLOod Warning System, the six-module ensemble can predict flooding due to heavy rainfall, sea-level rise and increase in water levels of the three rivers — Cooum, Adyar and Kosasthalaiyar — that traverse the city.

Ward-level data

"The State government shared data such as ward boundaries, population details, infrastructure available across Tamil Nadu, which have been used in the warning system," says M. V. Ramana Murthy, Director, NCCR. The topography data was obtained from the Indian Remote Sensing programme. "Next we plan to develop such a system for Mumbai city and Cochin area," he adds.

Knowing the elevation at different spots, the system can predict the way the area would flood based on different scenarios that have been simulated. Inputs were taken from the India Meteorological Department (IMD) on forecast and National Centre for Medium Range Weather Forecasting (NCMRWF), which gives the prediction for rain 10 days in advance. Similarly, INCOIS gives the hydrodynamic congestion such as storm surge and tide etc. Using this, the system can, two weeks ahead of the event, simulate the scenario. "The system can predict what would happen at the level of individual wards," says Tune Usha, scientist with the NCCR and one of the key persons behind the development of C-FLOWS. "We can now apply it to the Greater Chennai Corporation area of 462 sq. km," she adds.

Thus, early warnings could be issued. "The flood itself cannot be avoided, but it can be managed and the disaster mitigated," says Dr Usha.

The spatial database of the city which contains all administrative layers, details of

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ward boundaries, infrastructure, details of elevations and surfaces, soil, land use, geomorphology and census datasets are contained in the first module. There are many precomputed scenarios of flooding based on the forecast rainfall and tidal conditions, in a library. From this the most appropriate one may be selected for superimposing on the geomorphology. The second module has to do with this precisely. Simultaneously, models can also be run in real time based on actual datasets. Over this can be overlaid details of storm water drains and drainage fractions to enable pre-flood planning operations.

The 3D visualisation module makes possible a realistic visualisation of the flooding in various places such as infrastructure, buildings, roads, ward boundaries etc, by superimposing the model outputs on the layers of data.

Convergence

Data from IMD, NCMRWF, INCOIS and Tamil Nadu State government are brought together in an online hub along with the field data and the remote sensing data to observe the situation in real time. This is the fourth module.

Authorised personnel can use a mobile app, which has been developed alongside, to collect data from flooded areas such as geotagged photographs and add to the database. This fifth module helps capture the ground reality and provide primary information for decision makers to plan relief and mitigation operations.

The last aspect is a decision support system: this is an online GIS query portal which can answer questions on quantum of flooding in specific localities, flood proximity, for example, it can say which roads are inundated and suggest routes for planning relief operations and so on.

According to Dr. K Satyagopal, Principal Secretary and Commissioner, Revenue Administration and Disaster management, C-FLOWS will be integrated with TN-SMART, a portal being developed by his department.

Computational studies help decode brain's GPS

By studying the movement of virtual animals in computer simulation, a research

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team led by Srinivasa Chakravarthy, Department of Biotechnology, at IIT Madras has unlocked the navigation behaviour in rats moving in two dimensions and bats (3D). They hope to use these clues in engineering autonomous vehicles and drones.

Previous studies have shown that certain regions (hippocampus and parahippocampus) in the rat brain contain special cells known as “spatial cells” that help to create a cognitive map for navigation. The 2014 Nobel Prize in Physiology or Medicine was awarded to three scientists who discovered cells that constitute a positioning system in the brain. The inner GPS in the brain or the neurons help in coordinating the position, distance and direction of travel.

Using mathematical models and computer simulations, the researchers looked at these various spatial cells when rats move along the maze. One of the cells known as ‘place cells’ gets activated when the rat is at a certain place in a room and another type of cells called ‘grid cells’ coordinate this system and help in positioning and pathfinding.

“We developed a hierarchical neural network that simulated the neural GPS system reported from the brain of a bat during its flight in 3D space. The network not only explained the formation of 3D place cells but also predicted the existence of novel and yet undiscovered types of spatial cells that could potentially code for 3D space,” explains Karthik Soman from the Department of Biotechnology, IIT Madras, and first author of the paper published in Nature Communications.

One such spatial cell predicted from the computer model is a ‘plane cell’ that fires when the animal crosses a plane in 3D space. Another spatial cell predicted is a ‘stack cell’ that fires when the animal flies around multiple planes.

As bats are the only flying mammals, Michael Yartsev, one of the authors of the paper, and his group at the University of California Berkeley, further examined bats and the spatial cells in their brain while flying in a 3D space. Using wireless technologies, his group was able to monitor bats’ brain activity when they fly around and was able to show the functioning of the place cells in real animals.

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"We are now conducting more experiments on bats to check for more 3D spatial codes in the brain. We are looking forward to studying how brain processes large-scale navigation which we do seamlessly in our day-to-day life," adds Dr. Soman.

The researchers hope that an understanding of the spatial navigation system in the brain can also help in engineering automobiles, drones, and underwater vehicles.

World's smallest optical gyroscope developed

Scientists have developed the world's smallest optical gyroscope - a device that helps vehicles, drones and handheld electronic devices know their orientation in 3D space. The new gyroscope, described in Nature Photonics, is 500 times smaller than the current best device.

Originally, gyroscopes were sets of nested wheels, each spinning on a different axis, said researchers from the California Institute of Technology in the U.S. However, today's cellphones have microelectromechanical sensor, the modern-day equivalent, which measures changes in the forces acting on two identical masses that are oscillating and moving in opposite directions.

Sagnac effect

These MEMS gyroscopes are limited in their sensitivity, so optical gyroscopes have been developed to perform the same function but with no moving parts and a greater degree of accuracy using a phenomenon called the Sagnac effect, named after French physicist Georges Sagnac.

The smallest high-performance optical gyroscopes available today are bigger than a golf ball and are not suitable for many portable applications, researchers said. As optical gyroscopes are built smaller and smaller, so too is the signal that captures the Sagnac effect, which makes it more and more difficult for the gyroscope to detect movement, they said. Up to now, this has prevented the miniaturisation of optical gyroscopes.

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The device developed by Caltech engineers led by Ali Hajimiri can detect phase shifts that are 30 times smaller than the best systems currently available. The new gyroscope achieves improved performance by using a new technique called "reciprocal sensitivity enhancement." In this case, "reciprocal" means that it affects both beams of the light inside the gyroscope in the same way. Since the Sagnac effect relies on detecting a difference between the two beams as they travel in opposite directions, it is considered nonreciprocal. Inside the gyroscope, light travels through miniaturised optical waveguides (small conduits that carry light).

Imperfections in the optical path that might affect the beams (for example, thermal fluctuations or light scattering) and any outside interference will affect both beams similarly. Professor Hajimiri's team found a way to weed out this reciprocal noise while leaving signals from the Sagnac effect intact. Reciprocal sensitivity enhancement thus improves the signal-to-noise ratio in the system and enables the integration of the optical gyroscope on to a chip smaller than a grain of rice.

Decoding music's effect on brain networks

Listening to music has been found to improve our cognitive abilities but the mechanism in the brain that is responsible for the improvement has not been well investigated. Now, using electroencephalography (EEG) studies, researchers from Indian Institute of Technology (IIT) Kanpur have deciphered different mechanisms and alterations in the neural networks that lead to enhanced cognitive effects. The study was conducted on a small sample size of 20 male students from the institute. The students were made to listen to raga Darbari, and their brain activity was monitored using EEG, before, during and after listening to the music.

Special analyses — phase and power analyses — were carried out to understand the dynamics of neuronal networks and the underlying mechanisms behind them. They found increased power in the occipital and prefrontal cortex. "These are regions responsible for attention and decision making. An increase in their power shows an increase in efficiency," explains Ashish Gupta, research scholar at the institute and first author of the paper published in Scientific Reports.

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Spatial mapping showed that simultaneously there was also a reduced information flow predominantly between the frontal and parietal cortex. A total of about 170 connections interlinking the frontal regions with the central, parietal and temporal regions as well as the central regions with the parietal regions were found to have diminished communication.

"This reduced information flow signifies shutting off of irrelevant connections and depicts an efficient brain. This is linked with high IQ. Music is able to inhibit the distractive networks and excite only the ones responsible for cognition. Thus it saves energy for focused and efficient functioning. In other words, some specific music might have intrinsic property, almost like a password, to cause a higher quality of neuronal synchronic firing in brain cells, leading to enhanced cognitive ability," Gupta adds.

The researchers conclude that music might cause short-term enhancement of cognitive functions via a three-channel framework — purging off irrelevant networks (neural noises), increasing neural efficiency in the frontal lobe and enhancing attention by increasing the power in the occipital lobe.

"This finding is a part of our ongoing work on the influence of the deep conscious state on the brain. Music can possibly enhance cognitive functions of the brain as this work suggests," explains Dr. Laxmidhar Behera from IIT Kanpur and corresponding author of the work.

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IISER Kolkata develops simulation to predict solar activity over 10 years

Astronomers have observed sunspots on the surface of the Sun for nearly 400 years. It is known that sunspots follow a cyclic pattern of growing in number and disappearing in approximately 11 years, known as the sunspot cycle or the Sun's activity cycle. We are currently in the 24th sunspot cycle since the observation of this cycle began, in 1755. A team of researchers from IISER Kolkata have developed a way of predicting the intensity of activity in the next solar cycle (approximately from 2020 to 2031) using data spread over the last 100 years.

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Contrary to other calculations, they find that the Sun's activity would not dip during the next cycle, but it would be similar to the current cycle, perhaps even stronger. They expect the cycle to peak around 2024. The paper is published inNature Communications. "This is a unique data driven simulation work," says Dipankar Banerjee, Solar physicist from Indian Institute of Astrophysics, Bengaluru, who was not involved in this research.

The researchers simulate the behavior of the Sun using magnetic field evolution models and observational data. They simulate solar activity, and using inputs from observed data from one cycle, predict the behaviour of the Sun over the next cycle, about ten years in advance. Comparing their simulations with recorded data from 1913 to present, they show a remarkable agreement in most cases. Using the same method, they predict solar activity over the next cycle, about ten years into the future.

"Our work has shown that we cannot make a prediction beyond the next sunspot cycle (i.e., beyond the next 10 years) because the dynamical 'memory' of the Sun (i.e., the length of time over which past states affect future states of the Sun) extends only over one sunspot cycle and not beyond," says Dibyendu Nandi in an email. Prof. Nandi is with the Department of Physical Sciences, IISER Kolkata.

"This kind of work will be very important for the understanding of the long-term variations of the Sun and its impact on our climate which is one of the science objectives of Aditya mission. The forecast will be also useful for scientific operational planning of the Aditya mission," says Professor Banerjee.

Space weather

An important reason to understand sunspots is that they affect space weather. This refers to the effect of radiation, particle flux and magnetic flux in the region around the Sun. During extreme events, space weather can affect electronics-driven satellite controls, communications systems, air traffic over polar routes and even power grids. The other reason sunspots are interesting is the belief that they are correlated with climate on earth. A lot of the research in this area focusses on

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predicting the way the next sunspot cycle will shape up – whether the Sun will be extremely active and produce many sunspots or not.

There have been predictions that the next cycle (cycle 25) will show reduced sunspot activity. There have even been speculations that the Sun may be heading towards a period of prolonged low activity - what solar physicists describe as a 'Maunder-like minimum'. The Maunder minimum refers to a period from 1645 to 1715 where observers reported minimal sunspot activity — the number of sunspots reduced by a factor of nearly 1,000, over a period of 28 years. During this and other such periods of low activity, some parts of Europe and North America experienced lower-than-average temperatures. While the connection between the Maunder minimum and the climate on earth is still debated, it gives another reason to watch the sunspots.

"Sunspot cycle 25 may reverse the substantial weakening trend in solar activity which has led to speculation of an imminent grand minimum of sunspot activity and related cooling of Earth's climate" says Prantika Bhowmik, the first author of the paper who is a PhD student at IISER Kolkata.

Delhi researchers develop an algorithm to detect rare cells

Much like finding a needle in a haystack, identifying rare cells from a dataset comprising millions of cells can be hugely daunting. Now, a new algorithm developed by Delhi-based researchers makes it easy — it can find rare cells from a very large pool of cells in a matter of seconds.

The algorithm — Finder of Rare Entities (FiRE) — assigns a rareness score to each cell that is computed based on the gene expression profile of about twenty thousand genes. Cells having scores above a certain threshold are reported as rare cells. Besides being fast, initial studies show that the new algorithm has superior sensitivity and specificity compared with existing methods.

Circulating tumour cells, cancer stem cells, antigen-specific T cells, circulating endothelial cells are a few examples of rare cells. Rare cell populations such as circulating tumour cells can shed light on the process of cancer metastasis (spreading of cancer to other parts of the body) thus providing invaluable information for early

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detection and clinical management of the disease.

New cell type

While testing the efficacy of the algorithm using mouse brain cells taken from a specific region, the four-member team led by Prof. Jayadeva from Indian Institute of Technology (IIT) Delhi and Prof. Debarka Sengupta from Indraprastha Institute of Information Technology (IIIT-Delhi), Delhi discovered a new sub-type of pars tuberalis cell lineage. The authors have linked this newly found cell type to the development of the pituitary gland. The results are published in the journal Nature Communications.

Existing algorithms use clustering or other statistical techniques that involve rigorous parameter estimations, thus incurring a significant computational cost. “FiRE uses sketching, which is a variant of locality-sensitive hashing, to assign rarity to each cell. The hashing technique tends to put cells with similar properties together,” says Prashant Gupta from IIT Delhi and one of the first authors of the paper.

Tractable search

“Spotting an odd cell using existing tools becomes extremely difficult and complex when the number of cells becomes large. The FiRE algorithm makes searching for rare cells in large-scale single cell messenger RNA datasets tractable” says Prof. Jayadeva, who works in machine learning. “We used the gene expression of each cell to find the rare cells. The drop-seq, a state-of-the-art technique, allowed us to read out the gene expression profiles of thousands of cells in a fairly short time and then compared the profiles to find the rare cells.”

The researchers used five data sets to test the algorithm. In the case of peripheral blood containing 0.3% megakaryocytes, the gene expression of about 68,000 different cells was compared, and rare cell populations with different grades of rarity showed up. The cluster with the rarest cells comprised of only megakaryocytes, thus validating the algorithm.

In a simulation experiment to evaluate the performance of FiRE algorithm, the gene expression profiles of two types of cells were mixed in vitro. And by increasing the

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percentage (from 0.5 to 5%) of one cell type, the team tested the precision and sensitivity of FiRE and other existing algorithms to correctly identify the rare cells. The sensitivity of the FiRE algorithm was higher than the rest even when rare cells comprised 0.5% of the population. “When they constituted 2.5%, FiRE could identify rare cells with 85% accuracy, far higher than the other algorithms,” says Aashi Jindal from IIT Delhi and the other first author of the paper.

“We are now validating the new cell type [pars tuberalis] discovered using FiRE. Most malignant cancers shed circulating tumour cells. So we are also trying to use FiRE for early cancer detection by identifying the circulating tumour cells, which are rare in peripheral blood,” says Prof. Sengupta, whose lab pioneered single-cell genomics research in India.

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Agriculture

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AGRICULTURE

Blue roses may soon be grown in gardens

It may soon be possible to breed blue roses in your garden, say scientistsfrom Chinese Academy of Sciences and Tianjin University in China, who have found a way to express pigment-producing enzymes from bacteria in the petals of a white rose.

Earlier attempts

Although blue roses do not exist in nature, florists can produce blue-hued flowers by placing cut roses in dye.

In a painstaking 20-year effort, biotechnologists had earlier made a "blue rose" through a combination of genetic engineering and selective breeding

However, the rose is more mauve-coloured than blue. According to a study published in the journal ACS Synthetic Biology, researchers chose two bacterial enzymes that together can convert L-glutamine, a common constituent of rose petals, into the blue pigment indigoidine.

The team engineered a strain of Agrobacterium tumefaciens that contains the two pigment-producing genes, which originate from a different species of bacteria.

A tumefaciens is often used in plant biotechnology because the bacteria readily inserts foreign DNA into plant genomes. When the researchers injected the engineered bacteria into a white rose petal, the bacteria transferred the pigment-producing genes to the rose genome, and a blue colour spread from the injection site.

Spotty colour

Although the colour is short-lived and spotty, the team states that the rose produced in this study is the world's first engineered blue rose. They say that the next step is to engineer roses that produce the two enzymes themselves, without the need for injections.

Native shade trees better for carbon storage

The exotic silver oak may be coffee growers' preferred shade tree now, but research shows that it affects carbon sequestration and tree diversity in Kodagu's agroforest systems.

Kodagu's coffee farms were created when farmers cleared forest undergrowth and

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started growing coffee under the shade of giant evergreen trees. This 'native shade' coffee is still prevalent in the district, but evergreen trees are quickly losing out to the fast-growing silver oak. Farmers do not need permission from forest officials to lop or cut silver oak; this also contributes to its popularity. However, old forest trees make up a huge portion of carbon stocks here, and carbon stocks matter because the higher the carbon contained in vegetation, the more it helps with mitigating climate change.

Carbon stocks

To find out if carbon stocks change when silver oak takes over, a team including scientist ManjunathaMunishamappa from Bengaluru's Environmental Management and Policy Research Institute studied a total of 49 native and exotic agroforestry systems – where either robusta (which needs more sunlight) or arabica coffee varieties are grown – near 18 forest patches that fall under both moderate and high rainfall zones. In each plot (all spread across 22 locations along the Cauvery river in Kodagu), the researchers quantified shade tree species diversity and the amount of organic carbon sequestered in the trees by measuring wood, root, litter and soil biomass. Across all plots, the researchers identified a total of 86 native tree species; and the total carbon stocks rose with increasing tree diversity.

Native trees in coffee estates and forests displayed high and comparable carbon stocks (approximately 193 and 222 megagrams (Mg) of carbon (C) per hectare respectively) as well as tree diversity (around 45 tree species). However, the introduction of silver oak negatively impacted both carbon stock and diversity. Predictably, robusta coffee estates with silver oaks had significantly lower tree diversity (nine species) and lower carbon stocks (up to an average of 65 MgC per hectare) than all other land-use systems in both precipitation zones.

Current trends

Hence, the current trend of replacing native shade trees in coffee estates with silver oaks is detrimental for carbon storage and tree diversity, especially in robusta farms. Current policies do play a role in this change, because the exotics can be cut for

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timber without prior permission.

"We have submitted two reports to the Karnataka government on these findings, we hope some policy changes will be incorporated," he said.

NCBS: Loss of small RNA molecule is key to rice domestication

The domestication of rice can be tracked to the loss of a small RNA molecule (miR397), according to a study carried out at the National Centre of Biological Sciences (NCBS), Bengaluru. This can be used to improve crops.

Indica rice, a subspecies of Oryza sativa, was domesticated from two wild species: Oryza nivara and Oryza rufipogon. Both the wild species have weak stems and lie prostrate near edges of water bodies. The process of domestication selected useful traits from these: stronger stems, absence of seed shattering, more grains per plant, aroma, colour, etc.

For differences seen to manifest in the organism (phenotype), there should be corresponding changes in the genome. However, extensive studies found that the genomes did not show variation proportional to the changes in the phenotype. Researchers failed to identify genes responsible for the changes observed in domesticated Indica rice as compared to its wild relatives. The answer lay in regulatory molecules known as the small RNAs.

"Rice breeders found large regions in genomes that are responsible for a trait/ appearance - the Quantitative Trait Loci (QTL). There are 200 such QTLs identified for rice yield. However, only 20 of them have been identified at the molecular level when we initiated this study," explains Padubidri V. Shivaprasad of NCBS, in whose lab the study was carried out.

AGRICULTURE

Increasing lignin

Laccases are enzymes involved in polymerisation of monomers of lignin, which contribute to stem woodiness. If the plant produces more laccases then more lignin gets accumulated in the plant.

Small RNA dictate whether a gene may express itself and make a protein; they

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control the way genes express themselves in the phenotype.

After studying the two wild species, the domesticated high-yielding varieties and several rice lines in between (land races)—they screened 12 and sequenced 7—the team identified a small RNA controlling laccases; this is named miR397.

While miR397 is expressed in high levels in the wild species, it gradually reduces in intermediate forms.

They observed that miR397 regulated many aspects of rice growth including a change in the amount of lignin present in the plant.

“Increased lignin gives additional strength to the plant to bear more grains and that resulted in improved yield,” says Swetha Chenna, researcher from NCBS who is registered for PhD from SASTRA University and is the first author of the paper published in Plant Cell.

“In our study we show that at least 26 laccases including the miR397 fall into QTLs that are related to yield. These QTLs were identified by many labs worldwide, over many decades,” says Dr Shivaprasad. “This is the first report that reveals role of non-coding RNA regulators in domestication of any species,” he adds.

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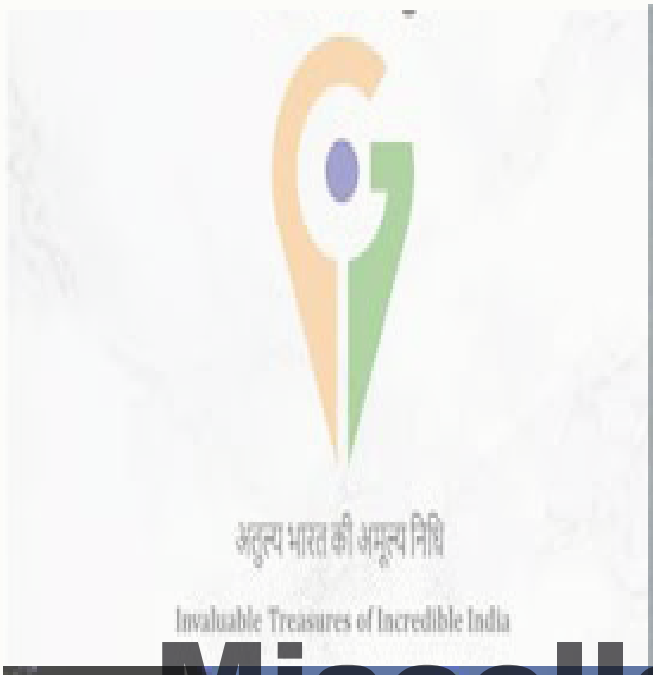

Miscellaneous

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MISCELLANEOUS

'Hold no brief for beef': Shifting diets for a sustainable food future

The World Resources Institute (WRI), based in Washington, DC, USA, has recently suggested that people should reduce (if not abandon) eating beef: This would warm the hearts of many vegetarians in our country, and the cockles of the hearts of the "gauraksha" lobbyists. But the reasons for this suggestion are not belief-based but deeper and come from the angle of worrying about the methods to achieve a sustained future for feeding the growing population in the coming years. WRI has come out with an eminently readable and well-researched report: Shifting Diets for a Sustainable Food Future (downloadable free on the net).

There are three interconnected arguments that they make here. The first is that many people eat far too much protein than they require for their daily needs. This is roughly true across all the world's regions and highest in developed countries. This is a waste. An average American, Canadian, European or Russian gobbles up 75-90 grams per day of proteins — about 30 g or so from plants and more than 50 from animals. What an average adult weighing 62 kg needs is no more than 50 g/day.

In comparison, Indians and other South Asians eat just about 52- 55 g/day (largely from legumes, fish and poultry). So do the Sub-Saharan Africans (though they eat meat a bit more than we do). But the problem however is that more people now from emerging economies such as Brazil or China are now aping the West and adding more beef in their diet. And WRI estimates that the global demands for beef may increase by a whopping 95% by the year 2050. This is despite the fact that beef-eating in the US has dropped, thanks to health concerns about eating "red meat."

By the way, the word cattle here includes cows and bulls, buffaloes, horses, sheep and goats - in effect farm animals. There are 1.3 billion cattle across the world today (and India rears 300 million of them). This means, we would need over 2.6 billion cattle 30 years from now!

The second point that WRI makes is that breeding cattle impacts the climate conditions on earth, contributing to global warming. It also takes up lot of land for pasturing (it is estimated that 25% of the earth's land mass (minus the Antarctica)

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would be needed for pasture). It is also estimated that a third of the global water is needed for farm animal production. On top of this, cows, buffaloes, sheep, goats and other "ungulates" belch a lot; this alone emits enormous amount of greenhouse gases that contribute over 60% to global warming. In contrast, plants such as wheat, rice, maize, pulses, roots and tubers need no pasture land, demand far less water and, more importantly, generate little or no "greenhouse gases". We have promised to cut down global warming to no more than 1.5°C within the next 20 years, but with the projected demand for increase the number of cattle, the situation can only worsen.

Do not overeat

Given this scenario, WRI suggests that we, the well-to-do people in the developed and emerging economy countries, shift our diets in the coming years, and do so in three ways. The first is "do not overeat"; in other words reduce the overconsumption of calories. We do not need 2,500 calories per day, 2,000 is ample. Today about 20% of the world overeats, leading to obesity and being overweight, and there are consequent health problems. Cutting the calories down to the optimal level will lead to both health benefits and saving in land and water use.

The second diet shift suggested is to cut down the consumption of proteins to the base recommended level, specifically by reducing the consumption of animal-based foods. When we do not need more than 55 grams of proteins per day, why gobble up 75-90g? Include more plant-based proteins and cut down animal-based ones. Traditional Mediterranean diet (fish and poultry meat, at low levels) and vegetarian meals (with legumes-based proteins) are suggested.

And the third diet shift is more specific. It says "reduce beef consumption specifically". Cutting down beef (cattle in general) in daily diet will offer both dietary and environmental benefit. The environmental benefits are clear; it saves agriculture for land use and reduces greenhouse gases. Rather than beef, one can turn to pork, poultry, fish and, of course, legumes.

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MISCELLANEOUS

Go vegetarian? vegan?

While WRI does not specifically advise this, it would help. This is of course a tall order, and demands a social and cultural shift. Mankind has been eating meat since millennia; persuading people to quit meat-eating would be Herculean. The main "beef" about meat-eating is beef! Moving on to pork, fish, chicken and eggs would be a culturally more acceptable start. Many health-conscious and climate-friendly people have already turned "flexi-tarians" (to use a word coined by a writer in The Economist, October 23, 2018) or "Mauka-tarians"(term used in the Indian Army where a normally vegetarian colleague occasionally enjoys meat as the opportunity ("mauka" in Hindi) comes by; your writer is one such).

The move to vegetarianism, which started around 1500-500 BCE by the Indians and the Greek, was connected with the idea of nonviolence towards animals, and promoted by religion and philosophy. The Tamil scholar-poet Thiruvalluvar, the Mauryan kings Chandragupta and Ashoka, and the Greek sage Pythagoras (of the theorem fame) were vegetarians.

The current trend towards an even more stringent form of vegetarianism, called the vegan diet, forbids any form of dairy products such as milk, cheese, curds, and indeed any animal-derived material. Today, there are about 300 million Indians who are vegetarians, and of these, perhaps about 2 millions might be vegans, but this might well need correction.

Rich diet lowers stress in crop-eating elephants

Elephants take a huge risk by feeding on agricultural crops. But this risk may be paying off in northern Karnataka: the rich diets could be lowering stress levels when compared with elephants in protected areas that don't raid crops.

Crop-raiding by elephants is common in agricultural areas near wild spaces that support elephant populations. Though it may look easy, crop-raiding is an enormous gamble for pachyderms. They face various forms of human hostility as farmers try to defend their crops. Wouldn't resulting high elephantine stress levels be a deterrent to such behaviour?

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To find out, a team of researchers from Bengaluru's Indian Institute of Science (IISc) compared stress levels of crop-raiding elephants in human-dominated areas in Hassan with that of non-crop raiding elephants in the protected areas of Bandipur and Nagarahole national parks. They studied levels of faecal glucocorticoid metabolite (fGCM), a stress hormone, in 602 samples of elephant dung to study the animals' stress signatures: the lower the fCGM levels, the lesser the stress. Surprisingly, non-raiding elephants in protected areas showed higher stress levels than Hassan's elephants.

Perplexed, researchers, including Sanjeeta Sharma Pokharel, decided to analyse food availability and diet quality available to these elephants. First, using maps, they examined the Normalized Difference Vegetation Index (a proxy for habitat quality or productivity, based on the values of greenness a habitat shows) of both areas. This clearly showed that agricultural zones had higher average NDVI values than the protected forests in both dry and wet seasons.

"This is obvious since the protected areas underwent the natural, seasonal differences in availability of forage while the agricultural landscape of Hassan was green throughout the year due to cultivation," says Dr. Pokharel.

However, greenness does not necessarily mean edible food for elephants. So the team went back to the elephant poop they had collected and quantified the total carbon and nitrogen contents in each sample to check if the diets in both habitats were of a different quality. Crop-raiders had higher nitrogen in their poop (a sign of higher protein in their diet) thanks to the high-quality crops they ate.

The study, published in Animal Conservation, suggests that it may be crucial to keep these physiological factors in mind while designing solutions to deal with man–elephant conflict, according to Dr. Pokharel.

For Delhi's black kites, it's a trade-off

Black kites in Delhi actively choose to live near humans, even accepting food that they offer. But the birds perceive people near their nests as potential predators,

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suggesting that they can react to people based on the context, shows a recent study published in the journal PLOS ONE .

In the country's capital, black kites – birds of prey that are at home in concrete jungles – have a close association with people. Studies show that they choose to live near areas of poor sanitation, thriving on associated small prey such as rodents and pigeons. The raptors also accept pieces of meat tossed to them by religious Muslims for whom kite-feeding is a centuries-old ritual. Yet, the main threats these birds face are human-made too: people sometimes collect kite chicks from nests for the illegal bird trade, while maintenance workers remove nests that pose a threat to electric wires or light poles. So is there a trade-off in how kites perceive people?

To find out, a team including researchers from Dehradun's Wildlife Institute of India surveyed 101 kite nests in the 1,500 square kilometres of Delhi city between 2013 and 2016. As they checked on each nest every 10 days for chicks, the team noted how the parent birds reacted to their presence. They scored each nesting pair on its intensity of nest-defense and compiled information from their earlier study to see if factors such as green cover and ritual feeding practices nearby influenced nest-defense.

Nest defense

They found that nest-defense by parent birds increased with the number of chicks in their nest and with the progression of the breeding season, suggesting that the adult birds increased their defense responses based on their parental investment (on the quantity and survival prospects of their chicks, which increased through the breeding cycle). Defense also intensified close to ritual-feeding areas that had higher human waste on the streets. Pairs that could invest in early aggressive defense during the incubation stage produced higher numbers of fledglings.

This ability of kites to discriminate between positive, neutral and negative human attitudes spells their urban success, said lead author Nishant Kumar (WII, and at the United Kingdom's University of Oxford).

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"Such context-dependent habitation and aggression to humans has been shown in other animals such as Australian magpies and rhesus macaques too," he said.

Therefore, coexistence with humans is often accompanied by "fine-grained, context-dependent strategies and trade-offs," suggest the authors.

Ape fossil 11 million years old unearthed in Gujarat

Tireless fossil hunting under the scorching heat of the Kutch basin, Gujarat proved fruitful and palaeontologists unearthed a fossilised upper jaw (maxilla). Further studies showed that the fossil find was highly significant: it is the oldest and the only known ape fossil discovered in peninsular India.

Ansuya Bhandari from Birbal Sahni Institute, Lucknow, stumbled upon the jaw in 2011 during a field survey with a group of palaeontologists from the Wadia Institute of Himalayan Geology, Dehradun, and IIT Roorkee.

The researchers concluded that the upper jaw belonged to an adult ape (hominoid family), belonging to the genus Sivapithecus and lived about 11–10.8 million years ago (Miocene). The oldest remains of these apes found so fari n Indo-Pakistan are dated at about 12.7 million years and the youngest at about 8.6 million years.

"Fossils of the Sivapithecus genus have been previously unearthed near the Siwalik hill range, spreading across Pakistan, Churia Hills in Nepal and around the Himalayas [Jammu and Kashmir and Himachal Pradesh]. Now this finding, almost 1,000 km south from the previous finds has increased the geographic range of the genus" says Dr.Bhandari, who is the first author of the paper recently published in PLOS ONE. "It also fills a time-window of approximately 11 million years in the evolutionary history of hominoid remains in India."

Ape relatives

She also explains that researchers now believe that Sivapithecus is either closer to the modern orangutan of Southeast Asia or an ape that is part of an early radiation of fossil hominoids — the great apes, the chimps, gorillas and orangutans and also humans.

Researchers from Duke University, U.S., carried out the X-ray CT scans. The

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researchers note that as the unearthed jaw had a lot of iron in it due to its deposition in an iron-rich ancient soil, the radiation was not able to penetrate very deep into the specimen, thus preventing better analysis. They hope that this finding will draw more attention to the region and more studies will be carried out in the future.

By comparing the fossil with other available data on Sivapithecus genus, the authors speculate that the identified jaw could belong to a large-sized ape, attributed to one of the two species of Sivapithecus, hysudricus or sivalensis. More, better-preserved and unfragmented specimens are required to identify the exact species.

"Kutch is a paradise for fossils. Many associated mammal fossils belonging to the Miocene age have been discovered here in the past, including whales and sea cows. The new discovery will help us understand in detail the evolution of great apes," says Sunil Bajpai from the Department of Earth Sciences at IIT, Roorkee and former director of Birbal Sahni Institute. He is one of the authors of the paper.

How green was my Diwali?

About 80 years ago, Richard Llewellyn wrote the book 'How Green Was My Valley'. This bestseller novel described how a mining town in Wales progressively deteriorated through deep and extensive mining into a contaminated shell. Some recent developments regarding (a) the use of firecrackers during Deepavali time, (b) the attendant noise and environmental pollution, exacerbating the already deadly air quality in many parts of India, and (c) the Supreme Court direction about the use of only 'green' crackers, and that too, only during two hours at night (which, too, was not honoured) reminds one of the Llewellyn's book.

What is a 'green' firecracker? It is one that should not contain elements such as lithium, antimony, lead, mercury and some others, which cause environmental and personal health issues. It also should not have high power explosives such as perchlorate, periodate and barium. This direction was given by the court, based on the recommendations of the Petroleum and Explosives Safety Organization (PESO) of India. Yet, as on date, Green firecrackers are not in the market. The Tamilnadu Firework and Amorces Manufacturers Association (TANFAMA) employs almost 1

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million people working in over 850 factories, with an annual turnover of Rs 5,000 crores. And TANFAMA declares that they do not use perchlorates and several of the above poisonous metals (which the Chinese manufactures do and export to India). They say that they use potassium nitrate, sulphur, aluminium powder and barium nitrate. Strontium nitrate is used for producing red colour, aluminium for sparkles and aluminium with sulphur for the cracker noise. Barium is used for the green colour. (By the way, this green is different from 'green', which is meant to be safe and environmentally less harmful; reading through this reminds one of the Borax Bead test done in college inorganic chemistry labs.) Red lead and bismuth oxide are also used. The TANFAMA website claims that the noise level of their products (about 125 decibels or db) is less than the European standard limit (131db).

Perchlorate and barium

Perchlorate, which has been used as an excellent explosive agent, is unfortunately very unsafe. It is known to affect thyroid gland function (by inhibiting the uptake of iodine) and might also be carcinogenic (Asha Srinivasan and T.Viraraghavan (Int. J. Env. Res. Pub. Health, 1414, 2009). A more recent paper analysed the contamination of ground water from fireworks manufacturing areas in southern India (Isobe et al., Env. Monitoring Assessment,October 2012) and found the levels of perchlorate in ground water and tap water in the fireworks factory area was significantly higher than safety limits. Thankfully, perchlorate is no longer used by firework makers in India; the import of crackers containing perchlorate needs to be banned.

Indian manufactures still use barium. This too is not 'green' but toxic. A population-based study found significant increases in the risk of death from cardiovascular (heart) disease in people above 65, who live in areas where drinking water has high levels of barium. That barium intake may affect the kidneys leading to neuropathy has been shown in rats and mice. One awaits data on how these are translatable to humans. Likewise, there is some worry about bismuth. While bismuth is less toxic

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than lead or antimony, bismuth-poisoning is shown to affect the kidney, liver and bladder. Here again the toxic levels need to be determined; see , for instance, metalpedia.asianmetal.com/

metal/bismuth/health.shtml

Delhi and its neighbouring states ahead suffer from terrible air quality (in terms of suspended polluting particles, automobile exhaust, smoke and smog) making them unsafe to live; many other cities across the country are sadly turning out to be mini-Delhis. To add to this is the practice of firecracker-burning, not only during festivals but even during marriages and community events round the year. We Indians seem to like to make noise and pollute the environment; any amount of restrictions by the city, State and the Supreme Court are not obeyed. Correction can come only from the individual, family, community and the obedience of law. Celebrations for us seem to mean noise and even more noise.

Other countries

Why is this true for Indian living in India and not elsewhere? Saptarshi Dutta wrote last year (in swachhindia.ndtv.com) on 'Regularizing and restricting sales and usage of firecrackers. What India can learn from these countries'. Many European countries, Vietnam, Singapore, UK and Ireland allow the purchase of firecrackers only around festival days (such as Christmas, National Day, Chinese New Year, Diwali). Many of the 50 states in USA have their own restrictions on the type of firecrackers and permit use not by individuals but by the community/city/state. Australia restricts the type of firecrackers (no air borne, no large explosion) and New Zealand permits fireworks only for four days of the year.

If Indians abroad obey these rules, why do we not do so in India? Unless the mindset changes, we cannot make a Swachh Bharat, despite whatever rules are imposed. To argue that faith and traditions need to be preserved holds no water. Concessions have been made by the governments both abroad and at home towards this. If firecrackers need to be burnt as a religious rite (is it?), why not do so with a token

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amount for a token time, and thus not defile the environment?

As we dip the Lord Ganesha idols in rivers and lakes, do we worry about whether they are environment-friendly? They were in earlier times, when we used mud to make these idols. What we do now is huge, environment-unfriendly and more exhibitionist than religious. KeerthikSasidharan wrote, “As rivers have become sites where the sacred and polluted coexist, our beliefs about the sacred no longer correspond with our intuitions about sanctity. How can devotees let the river become polluted, and does the pollution itself not render the river less sacred?”

As we blow firecrackers, do we worry about the attendant pollution? Is air not sacred?

IIT-M’s strategies to improve traffic efficiency

Traffic signals have been in use ever since automobiles became the preferred mode of travel. Yet, little has been done to improve their functioning, in comparison with innovations in automobile design. A group at IIT Madras has studied Indian traffic conditions and come up with three counter-intuitive strategies to improve efficiency of oversaturated traffic flow through road intersections.

In a preliminary study, Radhakrishnan, at present an assistant transport planner with Atkins, and GitakrishnanRamadurai from the Department of Civil Engineering, IIT Madras, collected data on the variation of headway, which is the distance between the leader vehicle and the following one. Observing vehicles at the traffic signals near three places in Chennai (Tidel Park, Tiruvanmiyur junction and Adyar depot), they found that the distance between two successive vehicles (headway) increases with duration of the green signal. This implies that longer the duration of green signal, there would be less throughput, thereby reducing the efficiency of the signal. Developing on this study, Dr Ramadurai arrived at the first strategy: keeping the duration of green signals short enough that the headway reaches a saturation value, in his paper in Communication Systems and Networks, conference proceedings published by IEEE.

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Bottleneck metering

The second strategy proposed in the paper is to have bottleneck metering along the lines of traffic control on expressways, near entry points and exits. Like highways, expressways have points where traffic leaves or enters through lanes, such as in T-junctions. These often experience bottlenecks because vehicles, not being in specific lanes, merge from different directions, thereby causing 'turbulence' in the traffic flow. The researchers collected data from arterial roads in Chennai where a four-lane one-way section of a road merges with a two-way section with two lanes in each direction in a T-junction. They monitored average flow of different types of vehicles before, during and after congestion for three days. They found that for two-wheelers and cars, there was an increase in flow once congestion starts, whereas for three-wheelers and heavy vehicles, the flow decreases. Overall, they found a capacity gain at the bottleneck, instead of a capacity drop expected from reported literature, and flows increase once congestion sets it. Taking such factors into account, they suggest that by placing signals separately for each lane that enters or leaves a bottleneck on an arterial road, and using green signals alternately, a higher throughput or a capacity gain can be engineered.

Storage space

The third strategy is based on the observation that two-wheelers have significantly lower headways compared with others; they also have negligible start-up delay. Also, in congestion, two-wheelers filter through the gaps and increase overall throughput. "We show that two-wheeler throughput can be increased significantly by providing them space upfront at a signalized intersection without affecting other vehicles significantly," says Dr Ramadurai. The idea is to have separate lanes for two-wheelers close to intersections and an exclusive two-wheeler storage space at the front where they can collect while waiting for the signal to change. A microsimulation model calibrated by S. Siddharth and Dr Ramadurai which was published in Proceedings of the Urban Mobility India 2013, conference, is used to

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test this idea. The simulation model showed a reduction in delay time of about 50% for two-wheelers and an overall delay reduction of 20%.

"The complex interactions [between different types of vehicles] are broken down by physically separating two-wheelers from three-wheelers, cars, and heavy vehicles and this may be a reason for smoother flow resulting in reduction in overall delays," explains Dr Ramadurai. However, he adds that real-world trials are required to validate this hypothesis since simulation models are only an abstraction of reality.

NCCS: Mass bathing during Kumbh Mela alters bacterial load, diversity

Bacterial populations in the river undergo huge loss in diversity but a steep increase in bacterial load when millions of people bathe at designated bathing sites during Kumbh Mela, a team of researchers has found. The loss in microbial diversity was nearly 37.5% while the increase in bacterial load was about 130-fold during the event.

The team led by Dr. Avinash Sharma from the National Centre for Cell Science, Pune, found that bacteria belonging to certain phyla reduced significantly while the prevalence of bacteria belonging to phylum Firmicutes (known to be also associated with human skin, stools and many infectious pathogens) was nearly 95%. The study was carried out in 2015 at five bathing sites in the Godavari River in Nashik and the results were published in the journalMicrobial Ecology. Samples were collected prior to and during the Mela allowing the scientists to compare the spatiotemporal changes to water quality and bacterial communities.

Infectious diseases

Besides changes in bacterial diversity and load, the study found an increase in infectious diseases and drug-resistant microbes in the river water samples collected during the Mela. There were elevated levels of genes related toHelicobacter pylori, Salmonella and Staphylococcus aureus. Elevated levels of drug-resistant genes include antifolate resistance, beta-lactam resistance and vancomycin resistance, to name a few.

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The water samples collected during the Kumbh Mela had much higher total dissolved solids and total suspended solids. The biological and chemical oxygen demand increased due to higher release of organic particles during the Mela compared with before the Mela. As a result, there was “substantial reduction” in the concentration of dissolved oxygen. “The substantial decrease in dissolved oxygen while the COD and BOD increased could be due to increased bacterial load in the water,” says Dr. Sharma.

While richness of bacterial species was higher upstream, at the bathing sites, the diversity dropped, and the bacterial community was dominated by few phyla. In all, 25 bacterial phyla were recorded and seven phyla (including Firmicutes) contributed to about 99% of the total bacterial diversity before the event. During the event, the diversity dropped by 37.5% and the diversity was restricted to just three phyla. The Fermicutes were the most abundant with over 90% at all the five bathing sites.

Bacterial load

Though the diversity reduced, the bacterial load increased 130-fold in samples collected during the event. Skin and faecal microbiota increased 2.3-fold and 2.9-fold respectively during the gathering. “By comparing the water samples collected before and during the event, we found a huge increase in infectious disease and antimicrobial-resistant genes during the Mela. These genes could pose a serious threat to public health,” he says.

Compared with skin microbiota, the faecal microbiota is predominant at one sampling site. “This site is located upstream and is a remote location and not a major bathing site. Because of this, open defecation might be more prevalent. This is my guess. We are yet to do any scientific study to ascertain the cause,” Dr. Sharma says.

New bacterium

During the same study, the researchers discovered a new bacterium, which they named Corynebacterium godavarianum, that showed resistance to antibiotics like amoxycillin, augmentin, cefpodoxime and clindamycin. The discovery was published

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in the journal International Journal of Systematic and Evolutionary Microbiology.

Awareness needed

"Our study highlights the need to create awareness among pilgrims to avoid open defecation and maintain personal hygiene to reduce the amount of microbes that get introduced into the river. A closed system for bathing prior to taking a dip in the river should be put in place to reduce contamination of human-associated skin bacteria," says Kunal Jani from NCCS and first author of the paper.

Besides taking a dip in the river, pilgrims also drink the holy water. "Drinking this water containing infectious disease genes and antimicrobial-resistant genes could pose serious health issues. It might be preferable to drink the holy water much upstream where fewer people bathe," he suggests.

IIT Bombay: New way to characterise thickness of layered 2D materials

The isolation of single sheets of carbon, known as graphene, was awarded the Nobel Prize in 2010. This discovery has ushered in an era of two-dimensional materials. It offers immense possibilities in building electronics using similarly thin films. A family of materials that have been investigated in this area are the transition metal dichalcogenides (TMDs), examples of which are molybdenum sulphide, molybdenum selenide, tungsten sulphide, tungsten telluride and so on.

Monolayer characteristics

It is necessary to know the characteristics of monolayers accurately if they are to be used in manufacturing or even designing devices. These include the thickness of the monolayers and the separation between pairs of monolayers. A study by Dhirendra Vaidya and others from Indian Institute of Technology Bombay shows that it is incorrect to use the value of the actual physical thickness of the monolayer. The researchers compare earlier electrostatic calculations with an atomistic (density functional theory) approach that takes account of the ionic potentials.

While the qualitative features match, they find that the former is inaccurate as compared with the latter when it comes to the quantitative features.

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The authors propose that this discrepancy is due to the tails in the ionic potentials, which extend into regions outside the edge of the ions themselves. “The genesis of the error is the protrusion of the chalcogen atomic potential into the space between the chalcogen-terminated layers,” says Swaroop Ganguly from the Electrical Engineering Department at IIT Bombay and an author of the paper published in Physical Review Applied. “We considered and eliminated another plausible explanation, namely the spread in the electron wave functions.”

Interlayer separation

This error becomes significant when the thickness of the device is small. “The disagreement is significant when the interlayer separation is comparable to the Van der Waals gap, or the natural separation between the bilayers,” says Dhirendra Vaidya, a PhD scholar at the department and first author of the paper. “If neglected, in the device analysis using the pure electrostatic model it can lead to a large error in the critical device parameters such as threshold voltage,” he clarifies.

This finding would be important in designing futuristic devices such as the tunnel-field-effect transistor (TFET) which stand to challenge the CMOS switch – the standard device used in electronics today. It is expected that TFET could serve the demands of high energy efficiency of Internet-of-things applications. The CMOS switch works by controlling the height of a thermal barrier and a potential of about 60 millivolt is needed to swing the current by an order of magnitude. On the other hand, the TFET works by controlling the thickness of a tunneling barrier, needing much less that 60 mV to effect the same swing.

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Animals as medical diagnosticians

A few weeks ago, there was an interesting news item which said that dogs can identify a person infected with the malarial parasite, and that they use their superb sense of smell to do so. A group called “Medical Detection Dogs,” a nonprofit foundation in the UK reported this finding in a recent scientific meeting in the US, and Donald G McNeil, Jr has written an excellent column about this in the New York Times (Nov 5, 2018, accessible on the web).

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Medical Detection Dogs had already done considerable work on the ability of dogs in detecting cancers of various kinds in humans, by smelling the different odours coming out from the tissues of the affected person's body, clothing and sweat, and have trained dogs to do so. Apart from detecting cancers and malaria, the group has found that dogs can detect type 1diabetes. Some other groups claim that they have trained dogs to detect the onset of seizures in epileptic patients. One would expect that several other illnesses would soon be detected using dogs as diagnostic agents. That dogs have the remarkable ability to sniff and detect volatile chemical compounds (notably molecules that smell) has been known for centuries. It is for this reason that security guards in airports, customs and other public places use dogs to smell and identify drugs, explosives and other objectionable materials. Dogs have of course been used for centuries in hunting for animals (rabbits, foxes) in hunting expeditions missions and in environmental missions.

How it began

Their use in medical diagnostics is rather recent, perhaps in the last 50 years or so. An excellent and early to read summary called "Animal Olfactory Detection of Disease: Promise and Pitfalls" has been published in the journal Clinical Chemistry (60:12,1473-1479,2014) which highlights interesting aspects of the use of dogs and other animals (notably the African pouched rats) for diagnostic purpose. (This paper is available online, free access, at DOI:10.1373/clinchem.2014.231282). That dogs could detect cancer was appreciated in 1989 when a dog persistently sniffed at a mole on the leg of a dog-handler. This skin lesion turned out to be a melanoma. Dr N. De Boer describes in the above paper how dogs have been able to smell cancers of various organs in our body, all of which have turned out to be true using laboratory diagnostic tests. More recently, dogs have been trained to correctly diagnose infection from certain microbes as well; some examples are M. Tb which causes tuberculosis, and clostridium difficile, which infects the colon.

Animals in general have a far keener and more versatile sense of smell than us humans. (Recall they came on earth far earlier than us and had accumulated such

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sensory versatility through evolution in order to cope with the environment. We lost some but gained some as Homo Sapiens). For example, Dr M. K. Bomers notes in the above paper that the Bedouins' camels (accompanying the nomadic Arabs) use their smell to find water through their detection of the odour of geosimin, a molecule found in wet dirt, as far away as 50 miles.

Rats can help

While we may not use a camel across the world to detect smells of interest, the giant African pouched rat is suggested as a possibility by Dr B. J. C. Weetjens in the above paper. He points out that their sense and spread of smell detection is excellent, they are easier transported, they need far less space, and they are robust and resilient to tropical diseases. But given the history of man and his domestication of the dog since millennia, the understanding and sympathy with each other, it is dogs (various types and breeds) that we have chosen so far as smell-detecting live instruments. Apart from dogs, the African pouched rats have been used as diagnostic agents in detecting some chosen diseases. The nonprofit organization called APOPO in Tanzania has been running a successful project using these rats. They are logistically less demanding - smaller in size, need less care and attention, can be trained quite easily, and transported far easier than dogs. They are now used in Tanzania and Mozambique, to detect pulmonary tuberculosis. (The site (https://www.flickr.com/photos/42612410@N05>, cited in the above paper is worth accessing in this connection. There must surely be other such local rodents, living in other areas of the world, which too can be tried for similar purpose.

The ability of animals like dogs, camels and rats to detect smells associated with disease appears due to the fact that they have anywhere between 150-300 million scent glands in their nose system, while we humans have but 5 million. This makes a dog smell 1000 to 10 million times better than us. This huge number allows for both diversity (for larger variety of smells) and sensitivity (for smaller amounts, and at more distant sources- note the ability of the camel). It is this great ability that has

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led dogs to detect the edible fungus, truffles, which lies under water, surrounding the roots of under-water plants).

Why not try in India?

India has a good dog training scheme which our crime branch, customs and forensic agencies use efficiently. Given the density of population, the ease of using rats in busy and rural areas, it might be a good idea to learn from the APOPO experience and attempt to train and use our local animals for quick and efficient detection of epidemics in the first instance; confirmation, if need be, can be taken up by sophisticated instruments-based diagnostic laboratories. This first 'point of care' detection can already help in alerting medical centres and health care workers to do the needful in terms of drug distribution, vaccination, and other measures to cut the spread. Our veterinary institutions might want to think about the feasibility of this idea, by choosing the best local animals, training them and deploying than in suburban and village health centres, particularly in states with high population density and limited diagnostic help.

IIT Bombay: Innovative spintronics device that borrows from optics proposed

A high-performance magnetic tunnel junction that makes use of wavelike properties that are known and exploited in optics has been proposed by researchers from Indian Institute of Technology (IIT) Bombay. They developed a quantum transport computational platform to predict the performance of such a device. If realised, the device can drastically improve existing standards of computing hardware and electronics. The results are published in the journalApplied Physics Letters.

A magnetic tunnel junction has two layers of ferromagnetic material separated by an insulating barrier. The ferromagnetic layers have the capacity to be magnetised along a particular direction. The spins in the ferromagnet contribute to its overall magnetisation. The magnetisation of the lower layer is fixed and that of the upper layer is free to align itself along any direction. The electrical resistance of the structure changes depending on the relative orientation of the magnetisation of the

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two layers. The device shows low resistance to current flow when the magnetistion of the two layers are aligned parallel and shows high resistance when the two are not parallel (pointing in opposite directions). Thus, if it can be made to switch from low resistance to high resistance, it can be made to function like a switch. The efficacy of the device is larger if the change in resistance is higher, also if it takes a smaller current to effect the change.

Similar to light

Electrons being quantum mechanical, can exhibit interference effects just as light can. Making use of this "wavelike nature" of electrons, the researchers propose a device which they name the band pass Fabry-Perot magnetic tunnel junction. They combine two phenomena seen in optics – anti-reflection and Fabry-Perot resonance – to design a spintronic device. "We achieve a very high spin filtering which results in high TMR (tens of thousand percent) and a large spin transfer torque in comparison with the typical MTU device," says Abhishek Sharma, PhD student at IIT Bombay and the first author of the paper, in an email.

Among potential applications is the magnetic RAM (MRAM) device that uses spin transfer torque. "MRAM is an emerging technology based on the electron spin, which is a fundamental property of the electron that should be distinguished from its charge," says BhaskaranMuralidharan, from the Electrical Engineering department of IIT Bombay, in whose lab the research was carried out. "It promises to deliver non-volatility [memory retention after it is switched off], high speed and low power dissipation, apart from offering the possibility of going beyond von Neumann computation architecture," Dr. Muralidharan adds. Von Neumann computation architecture is a standard architecture for computer hardware, in which the memory and RAM are separated.

A computer which uses the MRAM device would combine its memory and RAM functions, thereby greatly reducing the time taken to process instructions. This can revolutionise the computer hardware industry. The magnetic tunnel junction is a suitable candidate for the MRAM. It could also be used in fabricating spin

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transfer torque–based nano oscillators to achieve further miniaturization of wireless communication devices and brain-inspired neuromorphic computing systems.

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