News for October-December 2019

SCIENCE AND TECH.

THE CRUX OF THE HINDU

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Important News In the Field of

Space
Atomic Energy
Environment and Ecology
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Aspirant Forum

AN INITIATIVE BY UPSC ASPIRANTS

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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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Astrosat views star formation in jellyfish galaxies

Observations of a jelly fish galaxy, JW100, by Astrosat using its Ultraviolet Imaging Telescope have thrown up interesting puzzles. These puzzles involve star formation in hostile environments containing X-ray-emitting hot plasma. JW100 is located far away in the galaxy cluster Abell 2626. A recent work describes this analysis and poses the puzzle, vouching for the power of multiwavelength astronomy. The measurements made by the UVIT have been crucial for this work which is to be published in The Astrophysical Journal.

Jelly fish galaxies

Jellyfish galaxies are called so because they are shaped like discs that have many tentacle-like arms streaming away from the disc. They are formed when a disc-shaped galaxy rams into a galaxy cluster, which a dense region containing many hundreds or thousands of galaxies is packed into a small region. This can happen when the galaxy is attracted by the gravitational attraction of the cluster. As the individual galaxy rams into the galaxy cluster, the cold gas in its disc interacts with the hot plasma in the cluster. Acting like a strong wind, the plasma in the cluster strips away the cold molecular gas of the disc, causing it to stream behind like tentacles. Unlike usual galaxies that have stars forming in the disc, the jellyfish galaxies have star formation in the tentacles also.

The European Southern Observatory has an international programme led by Bianca Poggianti of Padova Observatory, Italy, to observe 100 such gas-stripping jellyfish candidates using the MUSE Integral Field SpectrographChile. This programme is called GASP (Gas Stripping Phenomena in galaxies with MUSE).

Astrosat joins this effort by contributing data from its Ultraviolet Imaging Telescope (UVIT) instrument. “We have already acquired data of many jellyfish galaxies with UVIT and the quality of UV images are amazing,” says Koshy George who is working on UVIT data. Dr. George is currently with Ludwig-Maximilians-University, Munich, Germany and has been working on this since his post-doctoral term at Indian Institute of Astrophysics, Bengaluru.

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The jellyfish galaxies' tentacles contain a very hostile environment as they interact with the galaxy clusters that are rich in X-ray emitting hot plasma. "What triggers star formation in these environments is a puzzle," says Dr George.

Multiwavelength study

The jellyfish galaxies are being observed by various telescopes each sensitive to different parts of the electromagnetic spectrum. The star formation in JW100 was gauged using observations of the visible (H-alpha) spectrum using the MUSE instrument of the Very Large Telescope in Chile and the ultraviolet imaging using the UVIT instrument of Astrosat.

Puzzling behaviour

One of the jellyfish galaxies that UVIT has collected data about is JW100. This galaxy is unusual because of its orientation. We see it edge-on so that the gas stripping can be seen perpendicular to our field of vision. It is also different from other jellyfish galaxies. In other jellyfish galaxies, star formation as estimated by the H-alpha observations matches with that calculated from ultraviolet observations.

In JW100, there is higher contribution from H-alpha but much less from ultraviolet in the tail. This could mean that other mechanisms such as shocks or thermal conduction from the hot plasma of the galaxy cluster is contributing to H-alpha emission from these regions.

"Jellyfish galaxies experience several mechanisms at the same time. Many of these happen over various timescales. The paper attempts to throw light on some of these mechanisms in JW100, using data which trace various components," says AnnapurniSubramaniam, director of Indian Institute of Astrophysics who was not involved in this work.

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Long-standing conundrum on the Sun's atmosphere solved

The Sun is one of the most familiar celestial objects – it is on the sky everyday. Yet, it harbours many a puzzle for the solar physicist. One of the puzzles concerns its surface and atmospheric temperature. An international team of researchers including

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one at Indian Institute of Astrophysics, Bengaluru, has had a go at this question. These observations may have unravelled why the Sun's atmosphere is hotter than its surface.

The temperature at the core of the Sun is nearly 15 million degrees Celsius, while that at its surface layer, known as the photosphere, is merely 5,700 degrees C. The natural thing to expect is that still further outwards, in its atmosphere, known as the corona, the temperatures would be comparable to that at the surface (photosphere). However, the temperature of the corona is much higher. It starts increasing outside the photosphere, reaching a value of about one million degrees or more in the corona.

Coronal heating puzzle

One would expect that as there are no extra sources of heat, when you move away from a hot object, the temperature steadily decreases. However, with respect to the Sun, after dropping to a low, the temperature again rises to one million degrees in the corona which stretches over several million kilometres from the surface of the Sun. This implies there should be a source heating the corona. The puzzle of coronal heating has been tackled by many theories. Now, in a paper published in Science, the team of solar physicists has made observations and matched it with an analysis that explains this conundrum.

Spicules in the Sun

The key to the puzzle lies in geyser-like jets known as solar spicules that emanate from the interface of the corona and the photosphere. While in a photograph these look like tiny hairlike projections, they are in fact 200-500 kilometres wide and shoot up to heights of about 5,000 km above the solar surface.

It has been suspected that these spicules act as conduits through which mass and energy from the lower atmosphere bypass the photosphere and reach the corona. The present study, led by TanmoySamanta and HuiTian of Peking University, China, has deciphered how these spicules form and also shows that they act as conduits through which hot plasma is carried into the corona region.

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'Our observations show that these spicules heat up while propagating upward, reaching the coronal temperature. They are made of plasma – a mixture of positive ions and negatively charged electrons," says DrSamanta. Objects at different temperatures emit light of different wavelengths. "The coronal plasma emits light in extreme ultraviolet. We find an increase in coronal intensity (emission) as spicules propagate upwards," he explains.

The team did their observations using the 1.6-metre Goode Solar Telescope at the Big Bear Solar Observatory (BBSO), the world's largest solar telescope, with the NIRIS instrument. "This is a high-precision instrument and can measure magnetic fields with high sensitivity," says Dipankar Banerjee, from Indian Institute of Astrophysics and one of the authors of the paper. The researchers also matched these observations with simultaneous observations form the Atmospheric Imaging Assembly in NASA's Solar Dynamic Observatory spacecraft.

Frequent images

The research involved taking many high-spatial-resolution images of the same region of the Sun within a short time. This is known as high-cadence. "Since spicules have a very short lifetime – from 10 to 100 seconds – to understand their dynamics, we need a higher cadence. This is also a limiting factor of many solar telescopes," says DrSamanta.

The key findings are that bursts of spicules originate from the boundaries of web like networks of magnetic structures in the surface. Near their footpoints, there emerge magnetic elements that have opposite polarity to the existing magnetic network. When the structures with opposing polarity run into each other, they cancel out. This was seen at the footpoints of some spicules. "Exactly at the time of cancellation, we found the presence of spicules, which are also responsible for heating the upper atmosphere," says DrSamanta, explaining how the spicules originate as per their observations.

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Weeding out black hole mimickers by looking at gravitational waves

In September 2015, the LIGO detectors in the US made history by directly detecting for the first time the merging of two black holes. Since then, LIGO, joined by other detectors around the world, has gone on to detect eleven events of which one is the merger of two neutron stars and the remaining ten, of pairs of black holes (binary black holes).

As they spiralled in towards each other and merged, the binary black holes let off characteristic gravitational wave signals. The properties of the merging black holes, namely the masses and spins could be arrived at by looking at the initial part of the signal waveform. Similarly, by carefully looking at the tail end – also known as the ring down part of the signal, the mass and spin of the final merged state (black hole) can be inferred.

The question emerges – whether other exotic objects exist that may act as black hole mimickers and give off similar signals. And if so, how is one to distinguish between such spinning black holes and exotic objects?

Theoretically, there are possibilities such as the so-called gravastars and boson stars which are black hole mimickers. For instance, a gravastar is a strange object that would have a core of exotic matter resembling dark energy with an external shell of normal star-like matter. “There are no observational evidences for their existence till date, but then, there were not too many ways in which one could look for them. Gravitational waves could be one…” says K. G. Arun, Chennai Mathematical Institute, Chennai, who led the study.

Gravastars spinning

The spinning of the compact object has a different effect on it whether it is a black hole or, for instance, a gravastar. Since the gravastar is filled with dark energy, it exerts a negative pressure on the outside. So when it spins it behaves differently from normal stars and black holes. When a normal star spins about an axis, it tends to bulge about the equator and get compressed at the poles. However, for a gravastar this effect is just reversed – It gets compressed near the equator and bulges out at

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the poles. Thus their shapes change differently when spinning.

"Any compact object, in general, can undergo deformations due to its spinning motion and these deformations are expressed in terms of what is called spin-induced multipole moments," says M. Saleem an author of the paper published in Physical Review D, who is a post-doctoral fellow at CMI.

"For black holes, due to the existence of event horizon, any property we measure from outside will depend on only its mass and spin, unlike other compact objects. This is the fact which we make use in our proposed test," he explains.

One property that can distinguish between a black hole and exotic object is known as spin-induced quadrupole moment. This parameter takes the value 1 for a black hole. "For other compact objects, the value ... of this parameter is different from 1 and will vary depending on the internal structure," says N. V. Krishnendu, the first author, formerly a PhD student at CMI, and now a post-doctoral researcher at Albert Einstein University, Hannover.

The researchers, including C.K. Mishra of IIT Madras, tested out their ideas on the events detected so far and found that the events of 2015, December and 2017, June were indeed just binary black hole mergers. These were the "low-mass" events for which their method is applicable. Further development of the idea can be used as a tool to discover exotic objects.

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Ramanujan's legacy used in signal processing, black hole physics

There is no question about the fact that mathematical genius SrinivasaRamanujan has left behind a rich legacy of problems in pure mathematics. What is surprising is that his mathematics, done over a hundred years ago, finds applications today in areas other than pure mathematics, which were not even established during his time (22 December 1887 – 26 April 1920). Two among these are signal processing and black hole physics.

Signal processing

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Examples of signals that are processed digitally include obvious ones like speech and music to more research-oriented ones such as DNA and protein sequences. These all have certain patterns that repeat over and over again and are called periodic patterns. In reality, complex repeating patterns may need to be identified as they bear significance to health conditions. So in signal processing, one thing we are interested in is extracting and identifying such periodic information.

The mathematical operation of identifying and separating the periodic portion is much like using a sieve to separate particles of different sizes. Some of the best known methods to extract periodic components in signals involve Fourier analysis. Using Ramanujan Sums is much less known.

"A Ramanujan Sum is a sequence like c(1), c(2), c(3) ... This sequence repeats periodically... It was thought by a number of authors before me to be useful in identifying periodic components in signals, much the same as sines and cosines are used in Fourier ananlysis," says P.P. Vaidyanathan who has developed these ideas over the last decade. He is the Kiyo and EikoTomiyasu Professor of Electrical Engineering at the California Institute of Technology, U.S.

Prof. Vaidyanathan came across this work in an interesting process that illustrates the role of friendly connections in the development of science. Several years ago, mathematicians H. GopalakrishnaGadiyar and R. Padma, from VIT, Vellore, were studying the twin prime problem when they observed that some arithmetical function which captures the properties of the primes should have a Ramanujan-Fourier Series.

They sent their paper to BhaskarRamamurthi, Director of IIT Madras, who in turn forwarded the paper to Prof. Vaidyanathan, a friend from his graduate days. Intrigued by the Ramanujan Sum mentioned in the paper, Prof. Vaidyanathan delved deep into it and developed the concept of "Ramanujan subspaces".

These ideas were further developed by his doctoral student SrikanthTenneti who showed that using these gave a method that worked better than Fourier analysis when the region of periodicity is short. "A number of extensions using two- and higher-

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dimensional generalisations for images and video, and extensions for non-integer (non-whole number) periods," are on the cards according to Prof. Vaidhayanathan.

Partitions of a number

Ramanujan was famously interested in the number of ways one can partition an integer (a whole number). For instance 3 can be written as 1+1+1 or 2+1. As the number to be partitioned gets larger and larger, the number of ways to partition it becomes difficult to compute. The seemingly simple mathematical calculation is related to a very sophisticated method to reveal the properties of black holes, as has been established by physicist AtishDabholkar, who is now Director, International Centre for Theoretical Physics in Trieste, Italy.

Ramanujan related this counting problem to some special functions called "modular forms". A modular form is symmetric, in the sense that it does not change, under a set of mathematical operations called "modular symmetry". "A geometric analogy for such a function would be a circle which does not change its shape under the 'circular symmetry' of rotations," explains Prof. Dabholkar. "Using this symmetry, Ramanujan and G.H. Hardy found a beautiful formula to compute the number of partitions of any integer."

Nearly modular

In his famous letter to Hardy in 1919, Ramanujan introduced the "mock theta functions" and observed that they were "almost modular". "A geometric analogy would be a 'mock circle' that is nearly circular but with a small blip," explains Prof. Dabholkar. "It is not easy to explain precisely what a 'blip' is, similarly, 'almost modular' remained a mystery for close to a century," he adds.

Following the work of mathematician S. P. Zwegers in 2002, in which he introduced "mock modular forms," giving a precise definition of what "almost modular" means, Prof Dabholkar's paper with Sameer Murthy and Don Zagier made the connection between mock modular forms and Black Hole physics.

Black Hole entropy

A separate concept in physics, entropy, explains why heat flows from a hot body

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to a cold body and not the other way around. The results of Ramanujan and Hardy on partitions and his subsequent work on what are called mock theta functions have come to play an important role in understanding the very quantum structure of spacetime – in particular the quantum entropy of a type of Black Hole in string theory, according to Prof. Dabholkar.

Stephen Hawking showed that when quantum effects are taken into account, a Black Hole is not quite black, it is rather like a hot piece of metal that is emitting Hawking radiation slowly. Thus one can associate thermodynamic quantities like temperature and entropy to a Black Hole.

"Mock modular forms are beginning to appear more and more in many areas of physics... Our work has also had unexpected applications in new topics in mathematics such as 'Umbral Moonshine', which are quite unrelated to black holes," adds Prof. Dabholkar.

"It is a tribute to the remarkable originality and power of Ramanujan's genius that the ideas he created a century ago are now finding applications in such diverse contexts," he says.

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Earth's innermost layer is capped by "iron-snow": Study

The Earth's inner core is capped by snow made of tiny particles of iron, much heavier than the snowflakes seen in the atmosphere, a study published in the journal JGR Solid Earth finds. The iron-snow falls from the molten outer core and piles up in the inner core of the Earth creating stacks that are up to 320 km thick.

Shape of Sun's corona accurately predicted

Solar physicists from Centre for Excellence in Space Sciences (CESSI), IISER Kolkata, have succeeded in predicting the shape of Sun's corona at the time of the annular eclipse on December 25. The corona is the outermost part of the Sun's atmosphere. This is the second successful prediction, counting the last solar eclipse that was viewed from South America on July 2 this year. While the earlier prediction

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differed slightly from the actual image, this time, it has been pretty close to the real thing. This was imaged by NASA and European Space Agency's space-based Solar and Heliospheric Observatory (SOHO) using the LASCO instrument. "For the South American Eclipse of 2 July, our predicted streamer tilts were slightly larger than observed at large distances from the Sun. This time, it is far better. We are still trying to figure out why this worked so well this time," says Dibyendu Nandi, who is a professor and Principal Investigator at CESSI.

Predicting in advance

The Predictive Solar Surface Flux Transport model developed by the CESSI team can predict the shape of the corona well in advance. PrantikaBhowmik, now at Durham University, UK, developed this model with Dr Nandi. "Our previous research indicates that we can predict the large-scale structure of the Sun's corona up to two months in advance. This is great, because this gives advance knowledge and a large window of preparedness for space weather driven by coronal magnetic fields," says Dr. Nandi. Space weather consists of the varying conditions such as solar wind and is different from weather on earth.

Space weather

"The dynamic events on the Sun can affect Earth's outer atmosphere and our technologies, leading to disruption in communication and navigation networks (GPS). These are more frequent during solar maxima and pose a threat to space reliant technology and astronauts," says Soumyaranjan Dash, PhD student at IISER Kolkata who works on this model.

This time, they had used inputs and made the prediction 43 days ahead of the eclipse. "The only way to verify these models is to either have photographs taken during the eclipse which captures the Sun's corona or use space- or ground-based instruments which use an artificial disc to occult the Sun's surface to make the faint corona visible," Dr Nandi adds in an email to The Hindu.

This time, since this was an annular eclipse with a ring of bright solar surface visible, the corona was not directly observable. The only option was to use a coronagraph

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with an occulting disc. “The only functional one in the world is in Hawaii in Mount Mauna Loa which has been having bad weather. Also it was night in Hawaii when the eclipse happened,” he adds. So the researchers used the images generated by the space based coronagraph instrument LASCO on board the SOHO satellite.

Atomic Energy

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Improving solar cell performance

Scientists have conducted an in-depth study on how carbon nanotubes with oxygen-containing groups can be used to greatly enhance the performance of perovskite solar cells. The newly discovered self-recrystallization ability of perovskite could lead to improvement of low-cost and efficient perovskite solar cells.

New class of quantum materials for clean energy technology

Researchers from IIT Bombay have discovered special properties in a class of materials called “semi-Dirac metals” that have been recently talked about in the scientific literature. Examples of semi-Dirac metals are systems such as TiO2/ V2O3 nanostructures. Through calculations, the researchers have shown that such materials would be transparent to light of a given frequency and polarisation when it is incident along a particular direction. The material would be opaque to the same light when it falls on it from a different direction. There are many known applications for transparent conducting films – the common example being touch screens used in mobiles. These results were published in Physical Review B.

“Our results in this paper show a very high optical conductivity of semi-Dirac materials for electromagnetic waves [light waves] of a specific frequency and specific polarisation” says AlestinMawrie, a post-doctoral fellow at Department of Electrical Engineering, and the first author of the paper. Optical conductivity is a measure of the opacity offered by the material to the passage of light through it.

What are Dirac metals?

Normal metals like gold and silver are good conductors of electricity. A key aspect that decides the quality of conduction is the way energy depends on the momentum of electrons. Dirac metals differ from normal metals in that the energy depends linearly on the momentum. This difference is responsible for their unique properties. Semi-Dirac metals behave like Dirac metals in one direction and like normal metals in the perpendicular directions (since their microscopic structure is different along the two directions).

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Within any material, charge carriers, such as electrons, acquire an effective mass which is different from their bare mass depending on the nature of the material. The effective mass and the number of states available for the electron to occupy when it is excited by an electric field, for example, determine the conductivity and other such properties. This is also true of a semi-Dirac metal. In particular, the effective mass becomes zero for conduction along a special direction.

Tailored for utility

"With the advent of man-made 2D materials, such properties have become quite tailorable in what comprises the active field of quantum materials," says BhaskaranMuralidharan, from the Electrical Engineering department and one of the authors. "One such example is that the [energy-momentum] dispersion relation can be linear, leading to large velocities and vanishingly small effective masses. The velocities can be over a100 times more than normal metals, thus increasing the mobility and currents that can be carried across devices made of these so-called Dirac materials," he explains. In the semi-Dirac metals, these properties are direction dependent.

In this paper, the authors have shown theoretically that the direction-dependence of the microscopical properties gives the material special optical properties.

Alongside, the duo also understood that the material should possess interesting thermoelectric properties. "Thermoelectricity is a clean energy technology that uses waste heat to produce electricity typically in low power applications," says Prof. Muralidharan. This technology is used in efficient cars, where it is used to keep lights on and to warm seats. Spacecrafts like Voyager which are too far from the sun to use solar energy can make use of thermoelectricity. "The holy grail of thermoelectrics is to increase the heat-to electricity conversion efficiency, for which there has been recent and tremendous interest due to the advent of nanomaterials and quantum materials," says Prof. Muralidharan.

Thermoelectric display

In a second paper published as Rapid Communications of Physical Review

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B, the researchers show theoretically that semi-Dirac materials can display such thermoelectric properties. This new work paves the way for experimental studies on realising this. The article also describes how to engineer atomic positions and defects to achieve exactly this effect.

Environment and Ecology

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ENVIRONMNT AND ECOLOGY

IISER Pune team synthesises photocatalyst to degrade organic pollutants

Researchers at the Indian Institute of Science Education and Research (IISER) Pune have successfully converted the highly unstable perovskite into a highly stable photocatalyst capable of decomposing toxic organic pollutants commonly present in water. The catalyst that becomes active when exposed to sunlight was synthesised by encapsulating nanocrystals of organic-inorganic perovskite inside a metal-organic framework (MOF).

The team led by Sujit K. Ghosh from the Department of Chemistry at IISER Pune utilised the hydrophobic nature of the MOF material to render greater chemical stability to perovskitenanocrystals that form inside the MOF cavities. The perovskite-MOF composites displayed “outstanding” stability when immersed inside water and alcoholic solvents for as long as 90 days.

Stable composite

The composites remained stable in water even when at boiling temperature for 20 days. While perovskite encapsulated by MOF showed 70% similar photoluminescence intensity before and after heat treatment at the end of 20 days, the photoluminescence intensity of naked perovskite decreased by 95% in just five hours of heat treatment. Likewise, the photoluminescence intensity of the composite remained almost intact even after being exposed to UV light for 20 days.

It is the hydrophobic nature of MOF that renders chemical, heat and photostability to perovskite.

The researchers found less than 1 ppb of lead metal leached from the composite at the end of 90 days of being exposed to different solvents, including water. “It is possible to replace lead metal with other nontoxic elements to make the composite more efficient and much safer to degrade organic pollutants,” says Dr. Ghosh. The results were published in the journal ACS Applied Nano Materials.

“This is the first time perovskite-based composite material as a photocatalyst has been used for the degradation of toxic organic pollutants such as antibiotics, dyes etc. It will be a cost-effective method to produce clean water,” says Dr. Ghosh.

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The researchers tested the composite's photocatalytic property to degrade organic pollutants in water. They tested three organic commonly seen pollutants — methyl orange, methyl red and nitorfurazone antibiotic.

Activated by sunlight

"When the composite was exposed to sunlight it was able to degrade the organic pollutants," says SamrajMollick from IISER Pune and one of the first authors of the paper. "When exposed to sunlight, the perovskitenanocrystals release electrons into water thus producing hydroxyl radicals. The hydroxyl radicals are highly active species that decomposes the organic pollutants."

But the rate of degradation of organic pollutants is not high compared with other standard materials. "Compared with other materials, perovskite is inexpensive. It is also possible to scale up its production easily," says TarakNathMandal, the other first author of the paper.

"This is only a proof-of-concept study. It is possible to increase the degradation rate by using different perovskite and MOF materials," says Dr. Ghosh.

The researchers were able to recycle the composite thrice and even on the third cycle the composite displayed over 90% degradation capacity.

Wild bonnet macaques gesture intentionally

Gestures are an important aspect of human communication. Until now, gestures in apes were believed to lie at the evolutionary roots of human language. However, a recent study on wild bonnet macaques implies that gestural communication — the basic tools for language — is observed even in that species. Given that monkeys diverged from apes (including humans) much earlier than humans diverged from other apes (such as chimpanzees and gorillas) this finding has an evolutionary significance as well. The study has been published in the journal BehaviouralProcesses.

Species ethogram

Anindya Sinha from National Institute of Advanced Studies, Bengaluru, who has been studying the behaviour of bonnet macaques in the Bandipur-Mudumalai region for close to 25 years, had developed an ethogram of the species. In essence, a

list of objectively-defined behaviours — an ethogram — becomes the reference document for subsequent studies.

Developing on this, the researchers recorded 32 independent gestures made by the bonnet macaques. Of these, they could not identify the context for eight gestures. For the remaining 24 gestures, they were able to identify the context of use. “It would have been perfect if we could get all the behavioursvideographed,” says Shreejata Gupta who worked on this problem, in an email to The Hindu. Now a postdoc at York University’s Department of Psychology, she explains how this made it difficult to address some features of intentionality, such as changing body orientation according to the receiver’s orientation.

Differential grooming

“When I first saw the bonnet macaques using their grooming gestures possibly referring to body parts that they intended to be groomed, I was absolutely elated…” she recalls. After accumulating more of these observations, the team published a paper on referential grooming in bonnet macaques, a cognitive capacity that was earlier believed to be restricted to human and non-human apes. This was published in the journal Animal Cognition .

“Bonnet macaques have voluntary control over their gestural communicative signals. They have a goal in mind, and they communicate with others to fulfil that goal. The entire process requires complex cognitive capacity, different from an involuntary action such as an alarm call at the sight of a predator,” says Dr Gupta. It has been known earlier that apes such as humans, chimpanzees, bonobos, gorillas and orangutans communicate intentionally. This study extends this behavior to monkeys.

“This continuity of similar cognitive processes underlying communication systems of monkeys and apes imply that our minds have had the building blocks of producing complex language for millions of years,” says Dr Gupta.

How female elephants compete for patchy food availability

Nakshatra and her group moved slowly down the grasslands in Kabini. They could

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see members of Victoria's group having a feast. In general, they would have avoided them, but Nandini rushed excitedly forward seeing a fresh green grass patch. She was stopped rather abruptly by someone who was aggressively pushing at her back with a strong trunk. It was Sunetra from Victoria's clan. Nandini, feeling Sunetra's strength, could only move back and join her group. Sunetra relaxed, having done her bit to retain the lush grass in the patch for their own use.

Recorded by researchers from Bengaluru, this is an example of a "contest competition" between individuals belonging to different clans of Asian elephant. Female Asian elephants usually move about in clans which are further subdivided into smaller groups of about four or five individuals. There is usually low interaction among individuals from different clans unless there is a competition for food or some other resource.

Personal touch

T.N.C. Vidya's group from JawaharlalNehru Centre for Advanced Scientific Research have been studying elephant behaviour and ecology for over a decade. They identify individual elephants by name using markers like ear shape, scars, pigmentation, etc. In this work, the group studied female Asian elephant clans in the grassland areas at Kabini, during the dry seasons of years 2015 and 2016. They videographed and counted three types of dominance (agonistic) interactions: (a) between individuals within a clan, (b) between individuals belonging to different clans and (c) between several members of two different clans.

The team found that between-clan individual-level agonism is more frequent than within-clan agonism. "This implies that the costs of between-clan contest are greater than within-clan contest in this small grassland habitat which becomes concentrated with several clans in the dry season," says HansrajGautam who is the first author of a preprint on the work, published in the preprint server BiorXiv. By costs, he refers to loss of feeding opportunity and increased stress from agonistic interactions. "These results suggest that the competition regime involves strong between-clan contest,

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which conforms to the grassland habitat being a small resource-rich habitat patch," he explains in an email to The Hindu. The grassland habitat has more than three times the grass biomass than in the adjacent forests.

Group size matters

The researchers found that as the group size increased, the number of within-clan agonistic encounters just scaled up. "This is because higher number of females means more competition," says DrGautam. Hence, having a larger group also has costs, which are related to within-group competition.

However, a previous study from the same lab found that larger groups tended to win against smaller groups in the grassland habitat. A strong force of between-clan contest might be keeping groups at sizes larger than the levels at which within-group competition would be minimised. This gives a way to test the results of the study: "We would like to quantitatively test this prediction in the future by comparing the group size observed in the two habitats," says DrGautam.

The study also shows how animal behaviour may be affected by inadvertently providing extra resources, says Dr. T.N.C. Vidya. She refers to the construction of the Beechanahalli dam over the River Kabini in the 1970s, which has led to the formation of the Kabini backwaters and the high grass availability that draws elephants and other herbivores to the area.

"This, we find, gives rise to high aggression between elephant clans," she says. "Because of this being a high quality large patch amidst forests that have lower grass availability, it actually creates more aggression between clans. It is one of the effects that anthropogenic changes like this can have," she says..

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Sikkim sees surge in butterfly biodiversity

From the iconic Kaiser-i-Hind to the recently rediscovered Small Woodbrown butterfly, the state of Sikkim is home to nearly 700 species of butterfly. A new study has found that the indigenous farming systems in this area are not affecting butterfly diversity. In fact, the team from Sikkim University found that organic farming has

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increased the species diversity. This was even higher than the diversity in the nearby forest ecosystem.

268 species identified

The team studied the large cardamom, mandarin orange, farm-based agroforestry and the natural forests in Sikkim and recorded a total of 268 butterfly species belonging to six families in these areas. The butterfly communities included two-third forest specialists, one-third monophagous (feeding only on one type of food), and one-fifth conservation concern species. The paper recently published in Ecological Indicators notes that "diversity was determined by tree species richness, tree density, canopy cover, elevation and mean annual temperature."

Bhoj Kumar Archarya, the team leader from the university's Department of Zoology explains that this study has helped break the stereotype that agriculture declines the wild biodiversity. The traditionally managed agroecosystems are not only the system for food production but are an important ecosystem that harbours habitats for different species of plants and animals. He adds that it is important to note that Sikkim is a fully organic state and results may vary when studied on farmland that uses chemicals. "To check this we have now started a study to compare the diversity of butterflies in the different agroecosystems in Sikkim and Darjeeling," he adds.

Those agroecosystems that still follow the traditional methods of cultivation and use organic manure pesticides "play a complementary role to the protected areas in fostering biodiversity conservation", adds the report. The team points out that most of the farms in Sikkim are small, and there is a mosaic landscape along with forests which creates very less impact on the natural ecosystem and allows various species to thrive. Also, the perfect elevation, cool temperature and ideal precipitation influence the diversity.

Monitoring the ecosystem

The team also identified 15 indicator species that can be used for long term ecological monitoring of the area. This included 11 habitat specialists, three monophagous, and two species that are protected under the Wildlife Protection Act 1972 (Schedule II).

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"These species are extremely sensitive and can survive only in a pristine environment. By tracking their numbers and behaviour we can find out if there are any changes in the ecosystem," explains Kishor Sharma, a PhD scholar at the university and first author of the study.

In an email to The Hindu, Prof. Archarya mentions a few steps that needs to be taken to protect the biodiversity. The agroecosystems need special protection in order to protect the wild biodiversity as there is no scope of extension of protected areas in lower elevation. Two, a synergy between agriculture, horticulture, forest and rural management department along with all stakeholders including farmers is required. Three, farmers should be encouraged and incentivised to maintain the diversity of the farmlands. Finally, more than monoculture systems, the focus should be on growing a variety of crops in a traditionally way and mixed crop farms to better conserve biodiversity.

As the Himalayan biodiversity has recently been facing threats from habitat loss, change in land use, forest fragmentation and urbanisation, it is high time the neighbouring states take notes from Sikkim and shift to traditional organic methods to preserve the biodiversity of the region.

The growing global trade in amphibian pets

Potterheads would remember Trevor, the pet toad of Neville Longbottom and how he made a getaway. Pet frogs and salamanders are not just confined to books and movies but are part of a rampant global trade, finds a new study. Just like Trevor's escape, accidental escapes or even release of these creatures into the wild is causing a rise in invasive species, adds the paper.

The study found that nearly 450 species of amphibians are traded globally. The two-member team from Stellenbosch University, South Africa tried to figure out what were the special traits that made these species preferable, how to tackle the entry of invasive species and also spread of diseases from them. Trade of pet amphibians has grown rapidly in the last few decades. A recent survey by the American Pet

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Products Association noted that about 5.6 million households in the U.S. owned a reptile or amphibians in 2012. Another survey pointed out that the industry was making annual revenue close to a billion U.S dollars.

What is traded?

The team analysed the available literature to find the traded amphibians around the globe and also looked at the amphibian database AmphiBIO and AmphibiaWeb to understand the physical characters and reproductive capacity of each of the traded species. They also noted the status of the species according to the International Union for Conservation of Nature.

Six amphibian families were the highest traded - salamanders, frogs and toads, followed by caecilians (limbless amphibians that look like snakes).

The top species (in terms of number of individuals imported) in the USA were: Western dwarf clawed frog, Oriental fire-bellied toad, African clawed frog.

The team noted that the species with larger bodies, wider distributions, and also species that had indirect development (where the embryo develops into a mature individual without larval stage) were preferred. This proves that species that are easy to collect and rear in captivity were the most traded.

Why amphibians?

Nitya Prakash Mohanty, first and corresponding author of the work published in Biodiversity and Conservation explains: “Amphibians are fascinating creatures that come in diverse life-forms: swimmers, climbers, burrowers and hoppers. These creatures are relatively smaller pets and probably easier to own than large mammals.”

Another paper published by his team in March looked at YouTube videos to understand why people prefer to have a pet amphibian. “There are thousands of videos which show pet frogs or salamander eating and or just walking around. I think it gives people an opportunity to observe or even handle a wild creature,” adds Dr. Mohanty. “Human preferences are not that easy to understand” he chuckles.

He explains that some people after buying these amphibians release them into the

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wild thinking it is an act of kindness or when the cost of ownership become too high. But the introduction of a species beyond its natural geographic range can harm native species. It can also lead to the spread of new diseases.

Studies have shown that globally over 100 amphibian species are marked as invasive and with the growing pet trade, these numbers will soon rocket up.

Choice matters

"Our models could be improved with more information about what attracts humans to keeping amphibians as pets. For example, bright colours and ornaments are likely to play a role in choosing an exotic pet," says John Measey, Principal Investigator of the team. "Our exercise was to look at amphibians in the pet trade, but the same approach could be taken with any taxonomic group to provide predictions about the future of the trade."

He adds that keeping a pet requires dedication and responsibility.

Comet impact led to Ice Age extinctions: Study

Researchers have found further evidence to support the earlier theory that an extraterrestrial body such as an asteroid or a comet may have crashed into the Earth almost 13,000 years ago, and caused the extinction of many large animals, and a likely decline in early human population.

The study, published in the journal Scientific Reports, noted that an asteroid or a comet hit the Earth, or blew up in the atmosphere 12,800 years ago, causing a period of extreme cooling that may have led to the extinction of more than 35 species including giant sloths, sabre-tooth cats, and mammoths in what is called the Younger Dryas climate event.

The researchers, including those from the University of South Carolina (UofSC) in the U.S., found further evidence of a cosmic impact based on research done at White Pond near Elgin in the US.

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How cotton leaf worm responds to the defence mechanisms of plants

A new side to the triangular story of interactions among plant, pest and predatory insect emerges as a result of a study carried out by researchers from the National Centre for Biological Sciences, Bengaluru. The team finds a link between the boosting of immunity levels in pest (cotton leaf worm, Spodopteralitura) and exposure to plant volatiles, which are aromatic vapours released by the plant when the worm chews the leaves. “This is the first study showing the impact of plant volatiles on cellular immunity of the worm [S. litura], causing elevated defense against natural enemies,” says RadhikaVenkatesan, in whose lab the work was carried out.

Natural triad

Take the example of the trio: cotton plant, the worm and the predator wasp Bracon brevicornis. When the worm feeds on the cotton plant’s leaves, the leaves release aromatic and volatile vapours into the air. These volatiles waft in the air and attract the wasps, which harm the cotton leaf worm. Though the adult wasp is an independent entity, the wasp lays its eggs on the skin of the worm, and when the eggs hatch, the larvae feed on the worm itself, thereby ending up killing it. In order to make this possible, the wasp first injects a toxic substance into the worm which immobilises it, so that the wasp can take time to lay its eggs on the skin of the worm.

Another example of such a triangle is the Cabbage worm Plutellaxylostella, and the wasp Cotesiavestalis. In this case, the wasp injects the eggs into the body of the worm and the eggs hatch inside and feed on the worm as they grow.

The experiment consisted of spraying the cotton leaf worm with plant volatiles and observing its change in immunity levels. “We exposed the [worm] to various plant volatiles for different time durations, then we collected the blood for immunological assays,” says Enakshi Ghosh who is a postdoctoral fellow at NCBS and first author of the paper published in Journal of Chemical Ecology. “As we observed that specific volatiles could modulate their immune status, we challenged the cotton leaf worm with its natural enemies — pathogen and parasitoid,” explains Dr Ghosh.

Induced immunity

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Six plant volatiles such as beta-ocimene and linalool were used in the experiment and each had different effects on the immune system of the cotton leaf worm. “In the case of beta-ocimene treatment, immune functions were enhanced that helped the worm combat wasp better.” says Dr. Ghosh. That is, being immune, the worm is not immobilised by the wasp’s sting. This prevents the wasp from laying its eggs on the worm. “In the case of linalool exposure, the worms survived better against bacteria,” she adds.

“It is interesting that beta-ocimene mediated immuno-modulation helped the herbivore [worm] survive better against parasitoid-like stress only, while linalool exposure caused increased survival against pathogen,” says Dr. Venkatesan. “The elevated defense caused trade-offs like reduced pupal size and adult life-span in these primed larvae compared to controls,” she adds.

Some of the questions that are raised by this study include - what happens when the worms are exposed to a mixture of plant volatiles, and whether this immuno-modulation is specific to Spodopteralitura . “It would be interesting to see if, in the race of co-evolution, there is any mechanism the parasitoids are building to combat heightened herbivore immunity,” says DrVenkatesan.

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India’s efforts towards mitigating climate change

At the recently held meeting on climate change at the U.N. in New York, the Swedish school student Greta Thunberg directed two scathing statements towards the attending representatives of over a hundred nations. One was, “You have stolen my childhood with empty words,” and the other: “You all come to us young people for hope (in mitigating the damage...). How dare you?” As Krishna Kumar’s perceptive analysis of her statements (November 1, issue of The Hindu) showed, the audience did not own up that their industries were responsible for the climate change; instead they agreed upon comfortable targets of decades for the reduction of carbon emission. As he points out, not only the richer nations but also the richer people in every nation continue to believe that they can buy relief and escape from the consequence of

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climate change for their progeny.

It is because of the carbon-rich fossil fuel-burning which started during the Industrial Revolution of the 1750s till today that the globe has warmed by about 2 degrees, affecting the lives of humans, animals, plants, and microbes. Oceans are warmer, icebergs are melting, and hence Greta's J'accuse.

India's challenge

It was in 2015 when nations across the globe met in Paris, and 197 signatory countries have promised to own up and to limit the increase to no more than 1.5 degrees over the pre- industrial levels by 2030. India is one of them. Vishnu Padmanabhan, in his blog, points out the four big climate challenges for India. India has promised to cut its emission intensity by 33-35% by the year 2030, as compared to 2015 levels. It looks like this is desirable and achievable. First challenge: Most of India's emissions come from energy (largely coal-based) production (68%), industry (20%), agriculture, food and land use (10%). It becomes vital that we use other means of energy, produced by, for instance, hydroelectric power, windmills, solar power, nuclear power and others. India hopes to produce 40% of its energy from such non-coal sources.

Next, turning to agriculture, land use and water resources, these too contribute to climate change. How? The minimum support price, subsidies, free 24-hour electric power supply, and water-intensive crops are some. It is high time we restrict these and take to proven methods, and work on innovative ones. Some of these are drip irrigation (as Israel has done), aerobic cultivation (a water- saving agronomic practice, and researching on improving specific traits that lead to better roots that go down to deeper levels in the ground, as initiated by the University of Agricultural Sciences, Bengaluru), better and more nutritious grains. Doing these on rice — a major water-guzzling plant of India — will go far in water conservation. More nutritious varieties such as the new Samba Masoori (developed at CCMB and NIPGR, which is incidentally lower in carbohydrate, hence good for diabetics) should be promoted among farmers. Stubble burning must stop; we need to find better ways. This is no 'rocket science'; Indian scientists and technologists can and should find ways that

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are better and safer.

The third is to bring down atmospheric CO2 levels through natural means. Forestation and planting of local varieties of trees must increase. Here, it is worth following the steps taken by the Philippines government. Each student there must plant and nurture 10 locally-suited trees before he/she gets a school certificate/ college degree. Note that local trees absorb water and send it down to earth. India has planned to create additional 'carbon sinks' through forestation and tree plantation, so as to bring down 2.5-3 billion tonnes of CO2.

Health issues

Several publications have focused on how climate change and global warming has gradually become injurious to health. The paper "Global climate change and infectious diseases" by Shuman (NEJM 2010, 362:1061-63; doi:10.1056/NEJM/09129310) points out, as we burn more fossil fuel, the temperature rise, associated heat wave and heavier rain make perfect conditions for insects (and the germs/viruses they host) to thrive. Thanks to the warmer climate, water-borne diseases such as cholera, diarrhoea, as well as malaria, dengue and chikungunya have increased in numbers and in geographical spread across hilly, cold as well as warm deserts and sea coasts. Another important paper by V RamanaDhara et al. (Climate change and infectious diseases in India: implications for health care providers, Ind. J. Med. Res. 2013: 138(6):847.852) points out how rising sea surface temperatures increase tropical cyclones and storm surges, leading to polluted water, insanitary conditions, population displacement, toxic exposures, hunger and malnutrition across the Bay of Bengal and Arabian Sea coast. Some are transmitted from animals to humans and of course human-to-human. The latest example is Nipah virus, transmitted by bats to humans. It is here that we should appreciate the prompt action taken by Kerala government in arranging to isolate people, work with biological labs in India and abroad to identify more such initiatives from State and Central governments.

Happily enough, many of our labs and drug companies are involved both in-house and collaborative research in order to design drugs from India's natural plant sources,

biosimilars, repurposing known drugs for other ailments and vaccines. We will be able to rise to the occasion and can even be world- leaders in this field. Note how our drug and biotechnology companies have provided drugs to the needy across the word at affordable costs, how just a handful of vaccine companies in India supply almost 40% of the world's childhood vaccines and how some of them are already working on vaccines for other current epidemics.

Oxygen bars are surely not a solution for pollution

The popularity of packaged air began around four years ago when a Canadian company launched 'canned air' for people in China when air pollution in many cities became alarmingly high. The newer addition — oxygen-bar — a recreational parlour or cafe which serves 'pure oxygen' is becoming a more attractive destination, particularly in cities with dangerous levels of air pollution. At times, the oxygen comes in different scented flavours.

In cities with highly polluted air, the business of 'canned oxygen' or 'oxygen-bar' is flourishing. The recent launch of such a recreational oxygen parlour in Delhi amidst the city's infamously bad air condition has caught significant media attention. But how safe are they and are any benefits at all?

First, do we really need this extra oxygen? The simplest answer is no. Unlike conventional oxygen therapies used in respiratory conditions that is administered for a short or long period in hospital or at home, people take oxygen for an ultra-short period in these bars (30 minutes or less). As per the standard clinical procedure, oxygen supplementation can be administered only in case of hypoxemia (lowering of oxygen saturation in the arterial blood below 95%) and it does not have any consistent beneficial effect on non-hypoxemic patients.

Placebo, at best

It must and should be remembered that the oxygen level does not alter in the air even when the pollution level is high. The same applies to our health — oxygen saturation in blood remains unchanged in healthy people in normal conditions, and

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such recreational oxygen cannot provide any health improvement. It can at best have a placebo effect. Though users and proponents of purified oxygen claim several benefits such as relieving stress, headache and migraine, and help in achieving better energy and mood, there is no clinical evidence available so far in support of the beneficial effects of recreational oxygen use.

Most importantly, the use of scented oxygen might not be safe. To add scent to oxygen, the oxygen is bubbled through a liquid containing scented additives or aroma oil. Users will seldom know the properties of the oils or the components of the additives used. Scented oxygen can be harmful to people, particularly to those with allergies and lung diseases. Fragrant materials very often contain aromatic hydrocarbons, many of which are potential allergens and can trigger asthma and allergic symptoms.

Moreover, the aromatistion of oxygen generates ultrafine droplets of essential oils which, when inhaled with oxygen, get deposited in the lungs and accumulate in the alveoli leading to a respiratory condition known as “lipoid pneumonia”. In this condition, deposited oil droplets can cause severe inflammation, damage alveolar septa (thin single cell lining between two adjacent alveoli) and interstitium (the area between an alveolus and its adjacent capillary) and lead to fibrosis. Long-term exposure to such exogenous oil substances may cause chronic lipoid pneumonia in which the patients remain asymptomatic and are often diagnosed at a very late-stage, and that too, incidentally, due to other illnesses. Among people with a lung condition, even a short-term acute exposure to such exogenous fragrance or oils can be life-threatening.

It must be borne in mind that oxygen-bars are sole-proprietorship ventures and are not legalised to administer oxygen for therapeutic purposes. These bars are not endorsed by local or federal healthcare systems and are not obliged to follow clinical bylaws, and thus cannot be held liable for any unwarranted health effect or an acute medical condition that occurs in the bars. Moreover, there are no statutory

warnings or guidelines available at these bars about the potential adverse effects, particularly applicable to vulnerable population such as children, aged and person with allergies or lung conditions.

Captivating yet unscientific

It is unfortunate that no medical community has come forward to spread awareness among people for this increasingly captivating yet unscientific business with no known or established clinical benefit. It definitely calls for serious vigilance by the clinicians and policy makers to ensure the safety issues associated with recreational oxygen use, particularly flavoured oxygen in such bars, parlours and spas.

Bats may be well adapted to forest fires

Bats may be well adapted to wildfire, according to a study which surveyed the effects of burn severity of 17 species of the flying mammal in forests that experienced fires.

The researchers, including those from the University of California (UC) Davis in the US, said while many forest bats are adapted to dense spaces, and others with open habitats, they found that species from both groups preferred burned forests to unburned or minimally burned forests.

To understand how wildfire was affecting bat habitat, they used an acoustic surveying technology with microphones that emitted very high frequency sound, and tracked patterns in the way bats communicated.

The recordings were converted into visualisations of bat calls, using which the scientists could identify the species present, and compare their occurrence rates to habitat conditions.

The study, published in the journal Scientific Reports, noted that while individual species responded to wildfire differently, the overall richness of bats increased from about eight species in unburned forests to 11 in forests that experienced moderate-to high-severity burns. This seems to suggest that many bat species seem to benefit

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from fire.

Peregrine falcon has fastest vision speed: Study

The peregrine falcon, one of the world's most common predatory birds, has the fastest vision in the animal kingdom and can register nearly 130 frames per second, according to a study published in the Journal of Experimental Biology. In comparison, humans see up to a maximum of 50 to 60 blinks per second. This is the first time scientists have studied the speed of vision among birds of prey, calculating how fast they see.

Musth does not necessarily give younger, male Asian elephants an edge

A seven-year study of Asian elephants from Nagarahole-Bandipur, a population centredaround the Kabini region, yields interesting patterns of male elephant behaviour when in musth. Hormonal levels give musth males high energy and aggression levels and this state is often correlated with a propensity to mate. In two papers published in Journal of Mammology and Gajah, the team from Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru, probes how this works in the Kabini population.

Elephants in musth

When an elephant is in a musth state, its urine shows increased testosterone levels. Also, temporin, a thick secretion, flows from the temporal ducts situated midway between their eyes and ears. Sometimes, the elephant dribbles urine as well. They hardly feed during musth and are more focussed on finding fertile females. They move from female to female, checking if she is fertile or not. Males enter into musth (show signs of musth) when there are in good body condition, and lost body condition over the time they are in musth because they are hardly feeding. Moreover, males can also mate when they are not in musth (they do not have to enter musth in order to mate). Therefore, people have been interested in finding out how exactly musth helps as a reproductive strategy since it is a very expensive strategy.

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One way in which musth might give an advantage is that it might help to break a "queue" so to say of which male elephant is allowed to mate. It is also possible that musth allows for males to have greater energy and to rove (roam) over larger areas, which then gives males the opportunity to sample more females than nonmusth males.

Data were collected by a seven-member team. The team members drove along pre-selected routes for nearly 12 hours starting early morning and took photos and videos whenever they sighted elephants on these paths. "We aged all the elephants based on relative height, and ratio of head size to body size, and identified all the individuals based on ear, back and tail characteristics since we have a database based on long-term monitoring," says P. Keerthipriya, a research associate at the Evolutionary and Integrative Biology Unit, JNCASR. Which individual male whether in musth or not was associated with which female was recorded.

No apparent advantage

The key findings of the group are that young (15-30 years old) males in musth did not have an advantage over older (over 30 years) non-musth males in terms of access to females. Old musth males had an advantage over old non-musth males, and also showed a roving strategy which allows for searching for multiple females. Therefore, musth seems to be a roving strategy that is primarily advantageous to old males and not to young males.

They also found that Kabini has a lower proportion of musth sightings compared to earlier studies from Kaziranga and Mudumalai. "Kabini has fewer males in the over-45 age class than Kaziranga and Mudumalai…. Hence the number of males of the 45 plus age-class seems to influence the occurrence of musth," says Dr. Keerthipriya.

Female elephants have a four-month oestrous cycle in which they are ovulating for three or four days only. Thus, for a male to find an ovulating female and mate with her is, even normally, a rare occurrence. Further, if the female should get pregnant,

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she is out of circulation for about five years, because the pregnancy lasts two years and then she is lactating for over two-and-half years. Therefore, females are a rare resource for males seeking to produce offspring. Therefore, male mating strategies become very important in such a species.

Competing males

In this context, the obvious feature is the high degree of competition that exists among males to select and mate with the few available females. This study analyses how musth might affect this competition.

"The young males probably have to wait it out and invest in growth rather than reproduction while the competition is mostly among the old males," says T.N.C. Vidya of the Evolutionary and Integrative Biology Unit, JNCASR, under whose leadership the work was done. "The low occurrence of musth in Kabini brings up interesting questions about how paternity will be distributed among males in Kabini, which is now being studied," says DrVidya.

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Can typhoid be an illness of the past?

The world is rid of smallpox. Globe-wide vaccination against it made this possible. We are close to getting rid of polio as well, and hoping that it too may no longer afflict us. Now, with a new vaccine against typhoid, made by an Indian vaccine manufacturer, Bharat Biotech of Hyderabad, that has been approved by WHO, typhoid, too, may soon be a thing of the past. The journal Nature Medicine called this one of the "Treatments that made headlines in 2018." The journal writes: And it is here that we read with pride that "The WHO has approved a vaccine against typhoid fever, called Typbar TCV, short for typhoid conjugate vaccine. It is the only vaccine deemed safe enough for use in infants starting at 6 months of age. This vaccine is the first conjugate vaccine — a vaccine in which a weak antigen (of the typhoid germ) is attached to a strong antigen (from the tetanus germ) to elicit antibody responses — against a bacterial disease (typhoid) that "affects up to 20 million people annually" (quote from Nature Medicine December 24, 2018, pp. 1780).

This vaccine Typbar TCV, whose creation and trial was first published by Bharat Biotech in 2013 (Mohan et al., Clinical Infectious Diseases 2015; 61(3):393-402; DOI: 10.1093/cid/civ295). This vaccine was tried in a unique human challenge model by an Oxford University group, and found to be superior to other competitive vaccines (made by e.g., Sanofi Pasteur, France). Based on this, the vaccine has been cleared for introduction in the National Immunization Programmes in Africa and Asia.

Vaccines for the world

Many people across even India do not realise that over one-third of the world's vaccines are made in our country today by just a handful of biotech firms and distributed across the Indian continent, Africa and Asia. All this has happened during the last 30 years or so. Until then, we imported vaccines made abroad and manufactured them here using the same process, on license. It is only when biotech firms forayed into the discovery of local strains of bacteria and viruses that indigenous creation of vaccines using modern biological methods began happening. Dr. ChandrakantLahariya has published an informative, brief history of vaccines and vaccination in India (Indian

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Journal of Medical Research 2014 April; 139 (4):491- 511: online accessible at PMID: 24927336).

Until recently, vaccine against typhoid was made by injecting live, but grossly weakened typhoid germs into the human body, provoking the body to mount immunochemicals called antibodies. Later, scientists found that it was not good to use live germs, since there are unwanted side-effects. Hence, they started using an important molecular component (the polymer that coats or covers the surface of the germ) which can elicit the same antibody from the injected 'host'. However, the treatment was not as effective or strong as we want. If only one can boost the immunological strength of the host! This was also tried using what are called carrier proteins added to the capsular polymer of typhoid germ. Several such carrier protein-based vaccines have also been tried and are in the market, even in India. A current paper by S. Sahastrabuddhe and T. Saluja which overviews the Typhoid Conjugate Vaccine Pipeline (Clinical Infectious Diseases, 2019; 68(S1):S22-26; doi: 10.1093/cid/ciy884) points out that Typbar-TCV has superior results on clinical trials, and is thus awarded WHO's pre-qualification and stipulations that allow for purchase by UNICEF.

Team science model

It is instructive in this connection to note what a Canadian group had written about the Indian vaccine industry (Chakma et al., Case Study: India's Billion Dollar Biotech. Nature Biotechnology 2010; 28(8):783.doi:10.1038/nbt0810-783; and also in Globalization and Health, 2011, https://globalizationandhealth.biomedcentral.com/articles/10.1186/1744-8603-7-9). (The group discussed how another creative vaccine manufacturer in Hyderabad, ShanthaBiotechnics, successfully introduced Hepatitis B vaccine across the world at affordable costs). The four important points that they pointed out for such success were: identify the therapeutic area and the scale of demand, investment and partnership, innovation through collaboration with scientists and clinics, and connect with national and global agencies- plus a current Good manufacturing Practice (cGMP) setup.

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And Bharat Biotech has done all these in good measure. In fact, their successful introduction of the Rotavirus vaccine is an early example of what has been called the 'Team Science Model' involving clinicians, scientists, national and global support groups, and the national government (see Bhan et al., Team science and the creation of a novel rotavirus vaccine in India: a new framework for vaccine development. Lancet 2014; 383 (9935): 2180-3. doi.10.1016/S0140-6736 (14)60191-4). Another such team science effort was their vaccine JenVac against Japanese Encephalitis (Singh A et al., Journal of Infectious Diseases 2015 Sep 1;212(5):715-25. doi: 10.1093/infdis/jiv023. Epub 2015 Jan 18).

And a fifth point: the role played by the India government, through its "Process Patent Law" of 1970, which led to the booming of private drug firms manufacturing global quality drugs at affordable costs across the world (for example, the Gandhian steps by Dr Yusuf Hamied of CIPLA in offering anti-HIV drugs at affordable costs to Africa, and KiranMajumdar Shaw of Biocon offering insulin at Rs 7 per day's need), and through recognition, grants and loans from the Department of Science and Technology and the Department of Biotechnology, Government of India, through research grants (including Biotechnology Industry Research Assistance Council, BIRAC), has been catalytic and praiseworthy. These have led to our vaccine companies offer quality vaccines for the entire world at globally affordable costs.

Protein rendering radiation resistance in cervical cancer found

ArathiSekhar (name changed) found herself bleeding even after menopause. She was diagnosed with cervical cancer and advised radiation and chemotherapy, together. Some of her tumours were found to increase after radiotherapy. Her treatment was stepped up and she is getting better. Not all late stage cervical cancer patients get so lucky.

Cervical cancer patients are treated with a combination of radiation and chemo therapy. The early stage disease show very good response but the in later stages of the disease some patients fail to respond to therapy.

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Protein identified

Sweta Srivastava and her team studied the molecular pathway in the tumours and found that some cells of the tumour, which are resistant to therapy, have increased expression of a particular protein (RhoC) which leads to enhanced DNA repair in cells exposed to radiation. Similarly, ROCK2 is another molecule that gets over expressed because of irradiation and protects tumour cells against radiation. The results were published in the Journal of Experimental and Clinical Cancer Research.

They conducted in vitro studies with tumour cells and found that treatment with an inhibitor (in this case an antibody) causes decreased expression of ROCK2 resulting in decreased DNA repair thus making the cells more sensitive to radiation. The inhibitor molecule was found after much trial and error. All the work was done in the St. Johns Medical College and Hospital, Bengaluru.

The presence of RhoC and ROCK2 in the tumour cells made the scientists suggest that the two molecules can be developed as predictive biomarkers for radiation response in cervical cancer. Additionally, following future advanced studies, these molecules have the potential to be used as targeted therapy leading to changed treatment of late stages of cervical cancer.

“Although this class of molecules has been studied in other cancers, the findings of this study will help in moving a step further in personalizing treatment of cervical cancer as well as help in identifying radiotherapy-resistant phenotypes prior to initiation of treatment for the very common cancer,” says Dr. Uma MaheswariKrishnaswamy, Professor and Head, Department of Pulmonary Medicine at St. Johns National Academy of Health Sciences, Bengaluru. She is not an author of the paper.

Lifestyle threat to gut bacteria

The evolution of dietary, widespread use of antibiotics and hygienic habits in Western countries is associated with a decrease in the bacteria that help in digestion. These

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very bacteria were also found in the Iceman, who lived 5300 years ago, and are still present in non-Westernized populations in various parts of the world.

Novel method found to kill dormant TB bacteria in stem cells

Delhi-based researchers have found that inhibiting lipid synthesis inside stem cells that produce bone cells (mesenchymal stem cells) can help in killing TB bacteria that are found inside the stem cells in a dormant state and safely shielded from the host immune system and TB drugs. While TB bacteria inside the macrophages actively divide, microbes inside stem cells lie dormant and also make the stem cells less likely to replicate thus surviving for an extended period of time. Ex vivo studies with human stem cells and work on mice showed that the two cells are programmed very differently to support active and dormant TB bacteria infection.

How bacteria hide

A team led by Gobardhan Das from the Special Centre for Molecular Medicine at the Jawaharlal Nehru University (JNU) found that TB bacteria are free in the intracellular fluid (cytosol) of the mesenchymal stem cells while they are surrounded by the macrophage cell membrane on being engulfed. This allows the bacteria to promote rapid synthesis of lipids inside the stem cells and hide within the lipid droplets so created.

The results were published in Journal of Clinical Investigation.

That mesenchymal stem cells serve as reservoirs of dormant TB bacteria was known but the mechanism by which the bacteria survive for a long period was not known.

“ S tudies using human mesenchymal stem cells and macrophages and mice model studies helped us understand how TB bacteria hijack the cellular mechanism to stop the stem cells from replicating and turn themselves dormant,” says Prof. Das. “The bacteria instruct the stem cells to synthesise lipids and hide inside them. The stem cells don’t kill microbes that are inside lipid droplets.”

There was sustained expression of genes controlling dormancy in the bacteria isolated from stem cells while genes that promote replication were expressed in bacteria

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isolated from macrophages. Mouse mesenchymal stem cells and macrophages too showed similar behaviour. In vitro studies using human stem cells showed the bacteria inhibiting stem cell replication.

When inhibitors to block lipid synthesis were used, there was reduced expression of genes that regulate dormancy of TB bacteria and replication of stem cells. “This helped confirm that TB bacteria induce lipid synthesis in stem cells and hide inside the lipid cells to escape from anti-TB drugs,” says Samreen Fatima from JNU and the first author of the paper.

Eliminating components

“Using a drug that inhibits lipid synthesis will prevent TB bacteria dormancy and make them susceptible to anti-TB drugs,” says Fatima. But killing the bacteria and preventing disease reactivation can be achieved by inducing autophagy (mechanism by which cells removes unnecessary or dysfunctional components) along with anti-TB drugs.

Inhibiting autophagy is one of the ways by which TB bacteria survive inside host cells. The researchers treated human macrophages and stem cells infected with TB bacteria with an anti-TB drug (isoniazid) and/or rapamycin. While isoniazid eliminated replicating bacteria found in macrophages, rapamycin induced autophagy in stem cells to kill the microbes. Similar results were obtained in mouse models too.

“In mouse models, inducing autophagy led to elimination of TB bacteria from stem cells. Addition of autophagy-inducing drug along with isoniazid led to sterile cure of TB and prevention of disease reactivation,” says Fatima.

“This discovery paves the way for finally getting to grips with the scourge that is tuberculosis in its dormant state, and whose resurgence poses a threat to not only treating TB but also to disease control,” says AnandRanganathan, a co-author.

Baby feeding bottles from the days of yore

A fascinating report by an European group of archaeologists led by Julie Dunne of the University of Bristol, UK has appeared in the October 10, issue of Nature (574,246-

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249,2019), titled “Milk of ruminants in ceramic baby bottles from prehistoric child graves”. The group was able to isolate baby bottles, some with an oval shape and a handle and some others with a small spout through which liquid could be poured or suckled. The earliest one found was during the European Neolithic age (around 10,000 years ago) while some others were found in sites from the Bronze and Iron ages (4000-1200 BC).

What makes the Nature paper even more interesting is the finding that the ceramic baby bottles had some organic chemical residues stuck on in their walls and could be analysed. The group was able to extract those residues and analysed the molecules in them, using the latest chemical and spectroscopic methods. All the extracts contained fatty acids (such as palmitic and stearic acids) which are common in the milk of cattle, sheep and such domesticated animals and not in human milk! The authors conclude thus: ‘the finding of these three obviously specialized vessels in child graves, combined with our chemical evidence, strongly points to these vessels having been used to feed animal milk to babies (instead of human milk) and children during weaning, as supplementary foods”.

When did animal milk feeding start?

The above paper had referred to an earlier report by Rachel Howcroft and others, from the archaeological research labs of Stockholm University, Sweden, with the catchy title “The Milky Way: The implications of using animal milk products in infant feeding” in the journal called Anthropozoologica (47-31-43(2012; downloadable free on the net. I strongly recommend reading it by the interested. (Incidentally, the term Anthropozoologica refers to interactions between us humans and other animals). This practice of using animal milk to feed human babies would have started only after the domestication of animals, which would have occurred when humans started settling in communities, started farming and domesticating animals for various uses. This is believed to have happened in the Neolithic period around 12,000 years ago, first in the Middle East, later in parts of Western and Central Asia and in parts of Europe. Community living, agriculture and farming started, and animals such as

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dogs, cattle, goats, camels (and later horses) were domesticated and put to use for human needs. Until then we were hunter-gatherers, and the only milk that human babies had was their mother's and weaning would have happened only after the infants grew to about two years of age.

The Neolithic Age changed the dynamics of human behaviour, fertility increased, the female work pattern had changed such that weaning of babies would also have started earlier. It also meant, as Howcroft and co-workers argue, that human babies were introduced to complementary food such as animal milk. This also appears to have enabled human mothers to vary their reproductive strategy (how many babies, how often and how early to wean).

We domesticated dogs anywhere between 10,000-4400 BC, cows and sheep around 11000-9000 BC, camels around 3000 BC and horses too around the same period. Yet we use only the milk of cows, goats and sheep not of the other animals mentioned above, although it appears that Africans did use camel milk, This choice of ruminants (that is, cattle, sheep, goat and camels, which have a compartmentalised stomach, where the food is quickly swallowed and chewed and sent off to the rumen, which is the main digestive system) seems to have came about through a trial and suitability experience by us. Note that we did/do not use milk from dogs or horses - wonder why?

How ruminant milk differs

Howcroft and co-workers, in their paper, have done a comparison of the contents of human and ruminant milks. Compared to ours, sheep milk has a higher solid component: less water, less carbohydrates, more protein and lipids and higher energy content. While the higher protein content might be related to the rapid growth of bottle-fed infants, it could also lead stomach acidosis and diarrhoea. Cow's milk, with a slightly lower protein and fat content than sheep's (though still three times higher than human milk), can also cause the same symptoms as sheep milk. Plus, ruminant milk lacks certain enzymes that human milk has, and thus is not as effective as human milk in fighting infection and in helping mineral adsorption. Given these

differences, some protective and some deficient, it is best that ruminant milk is used as complementary to, rather than replacing human milk completely. This is what early humans did through observation and adoption. This also would have led them to invent and use “baby feeding bottles” and jugs made of ceramics.

The authors further argue that fermenting milk (which, upon storing, produces yoghurt) helps to preserve it, reduce the lactose level and help digestion, thanks to the level of the enzyme lactase. They conclude that “although the milky way may not have been the best for prehistoric infants, the yoghurt way could have been good both for them and for the spread of lactase persistence”.

Last, VasantShinde and associates from Pune had done extensive survey of sites from the Harappan Civilization in India, and have solid evidence of Ceramic Feeding bottle from the Harappan site of Kalibangan dated to 2500 BC. The Harappans too weaned their babies with animal milk. Which animal? If we can at all find any residues from these bottles, and have them analysed in our labs, a la Dunne, that would be exciting!

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Stimulating white blood cells helps clear TB bacteria

Instead of using drugs to directly kill TB bacteria, researchers at the Indian Institute of Technology (IIT) Ropar have directly stimulated the immune system to kill the bacteria. This was achieved by using small molecules (ligands) to stimulate two specific receptors (CLEC4E and TLR4) found on the surface of white blood cells (macrophages) to kill the bacteria. The two receptors are copiously expressed on the surface of the macrophages, and activating them help regulate the cell function.

Once activated, the ability of the macrophages to reduce the TB load and eliminate the bacteria gets enhanced through increased autophagy. Autophagy is the body’s way of cleaning out damaged cells, in order to regenerate newer, healthier cells.

Through in vitro studies, the team led by Javed N. Agrewala from the Biomedical Engineering Department at IIT Ropar first tested the ability of the two receptors to activate the macrophages to kill the bacteria. The macrophages were first infected

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with TB bacteria and stimulated for 48 hours by activating the receptors using the small molecules. Compared with controls, the stimulated macrophages exhibited increased bactericidal activity. The enhanced bactericidal activity was confirmed using animal models.

Many firsts

Similarly, the enhanced expression of autophagy-related genes in macrophages was first observed in the lab and confirmed in animal models by IIT Ropar researchers in collaboration with CSIR-Institute of Microbial Technology (IMTECH), Chandigarh.

The specificity of the receptors to regulate macrophage function was tested using inhibitors which block the functioning of the receptors. There was increased survival of the bacteria in the macrophages on inhibiting the receptors.

To reconfirm the role of the receptors in inducing autophagy, the researchers abrogated the autophagy in macrophages and tested the ability of the activated receptors to clear the bacteria in mice models. “The ability to clear the bacteria was absent when autophagy was inhibited. This helped confirm that receptor-mediated elimination of TB bacteria in macrophages was through autophagy,” says Prof. Agrewala.

Besides in vitro studies and mice models, the activated receptors were found to reduce the TB burden when tested on human macrophages too. The results were published in the journal Autophagy.

Compared with controls, the potency of anti-TB drugs — isoniazid and rifampicin — to kill the bacteria dramatically improved when the two receptors were also activated. With rifampicin, the ability to kill the bacteria was seen even at one-tenth of the dose. Greater effectiveness at reduced dosage was seen only when rifampicin was used along small molecules that activated the receptors. Also, the ability to clear the bacteria was achieved with just two doses of rifampicin.

Enhanced action

The enhanced potency of anti-TB drugs when used along with the small molecules that stimulate the receptors was seen in animal models, too. In mice, there was

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significant reduction in bacteria load in the lungs, liver and spleen compared with controls. The number of granulomas in the lung too decreased.

Even in Guinea pigs, there was significant decrease in bacterial load and increased efficacy of the drugs to kill the microbes. The lungs and spleen of Guinea pigs treated with small molecules and TB drugs exhibited nearly normal morphology compared with controls.

"The activating the receptors have an immunomodulatory role in reducing both the dose and duration of treatment using anti-TB drugs," says Prof. Agrewala. "Since the receptors only activate the macrophages and do not directly act on the bacteria, there are fewer chances of emergence of drug-resistant strains of TB bacteria."

In mouse and Guinea pig models, there was proliferation of certain T cells that offer protection against TB bacteria. Also, there was significant increase in the number of memory T cells that provide long-lasting protection against TB bacteria thus signifying protection from subsequent infection with TB bacteria.

Heart disease risk high in rural area near Chennai

Contrary to the general notion, cardiovascular disease is becoming an important preventable cause of events (heart attacks and stroke) and death even among the rural population in India, a study shows. The study involved 5,641 adults aged 25-64 years living in a rural area near Chennai and followed up for nearly eight years. There were 96 deaths — 79 from heart attacks and 17 from stroke. There were 59 adults who suffered but did not die from heart attack and stroke.

The study, which began in 2005, was carried out in five villages in Tiruvallur district near Chennai. While baseline data were collected in 2005 and two follow-up surveys were carried out in 2008-2009 and 2013-2015.

The study was carried out by a team led by Dr. Prabhdeep Kaur from the Chennai-based National Institute of Epidemiology (ICMR-NIE). The results were published in the journal BMJ Open .

Hypertension, which is a huge risk factor for cardiovascular disease, was prevalent

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in 21.6% of men and women, while tobacco use was high both among men (nearly 35% smokers) and women (43% smokeless tobacco). Central obesity was also high both among men (20.2%) and women (26.4%). Alcohol use was high among men (28.6%), while diabetes, which was self-reported, was 4% in both men and women.

"Two-thirds of people who developed cardiovascular disease died. This could have been prevented. The risk factors were causing two times or more risk of cardiovascular disease," says Dr. Kaur. "Reducing tobacco use and treating hypertension and diabetes and keeping them under control could have halved the number of people getting stroke or heart attack."

Hypertension was a risk factor for both men and women. In the case of men, smoking turned out to be a big risk factor while it was central obesity and diabetes that were risk factors for women.

"With cardiovascular disease becoming an important preventable cause of death in rural areas, there is a compulsion to focus our attention on rural areas too," says Dr. Kaur. "Early diagnosis, treatment and regular follow-up to ensure control of hypertension and blood sugar will help people through their lifetime."

Dr. Kaur does agree that getting people to achieve control of hypertension and blood sugar is a huge challenge. With an estimated burden of 200 million people in India, hypertension is the most important noncommunicable disease risk factor. Many studies have shown that reducing hypertension by 20 mm mercury in people aged 4-69 years can help achieve a 50% reduction in coronary heart disease.

However, as per a May 2019 study published in PLOS Medicine, In India, only about 45% of people with hypertension were even aware of their diagnosis, hardly 13% were under medication and a paltry 8% had hypertension under control.

Superbug crisis: Are doctors to blame?

Antimicrobial resistance (AMR) is considered one of the most significant challenges the world faces today. To keep it simple, let us use the term superbug crisis instead

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of AMR. Globally, thousands succumb to untreatable superbug infections on a daily basis. Irrational antibiotic usage is a major reason behind this.

Major causes

Are doctors to blame for the crisis? Excessive usage of antibiotics creates resistance, and doctors are notorious for this. But it may surprise many that over two-thirds of the antibiotics manufactured by the pharmaceutical industry are used as growth promoters for poultry and cattle. An article published this year in Science points out that globally 73% of all antimicrobials sold are used in animals raised for food.

The remaining one-third is used to treat human ailments. Of this, the common public purchases more than half without a doctor's prescription, according to WHO. That leaves us just 15% of the global antibiotic production for the doctors to use and misuse. Let us say doctors utilise half of this for rational indications. Hence, doctors have to bear the cross for 10% or less for global antibiotic misuse.

Antibiotic stewardship is considered to be the most important intervention to tackle super bug crisis. A remarkable, though unachievable, 100% success of antibiotic stewardship among doctors to rationalise antibiotic use can correct only one-tenth of the global antibiotic misuse. Should we not invest our limited resources and efforts in other more fruitful components?

Over the last 10 years, antibiotic stewardship efforts by various medical societies in our country and other stakeholders including the Chennai Declaration have significantly raised awareness of the super bug problem among the medical community. It is doubtful whether this awareness translated into rational antibiotic usage. Lack of infrastructure and inadequate diagnostic facilities in our health-care sector is one of the major triggers of the irrational antibiotic use by doctors and the public. Unless we correct the root causes, it is very unlikely that in a country like India with a million doctors and half a million pharmacies, rational antibiotic usage can ever be implemented.

I do not dare question the relevance of antibiotic stewardship as a patient safety measure. Rational antibiotic use is choosing the right drug at the right dose at the

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right time. No doubt this is one of the cornerstones of modern medicine practice. Successful antibiotic stewardship programmes may make some impact in countries with good sanitation standards. However, it is doubtful whether this component will make any real difference in superbug rate in developing countries.

Priority factors

Improving cleanliness in hospitals and sanitation in the community is much more important than antibiotic stewardship. In countries with high existing superbug rate and sanitation issues, rational antibiotic use, unless it is comprehensive, may not help reverse the rate or halt its progression. There are many scientific publications that underscore this argument. There is no conclusive evidence to support antibiotic stewardship as an effective measure to reduce the Gram-negative superbug bacteria, such as E. coli and Klebsiella, the most prevalent group in South Asia.

Mistaken notion

Unfortunately, the medical community is under the erroneous impression that doctors created the superbug crisis. It is high time doctors come out of this. The medical community must emerge from the never-ending antibiotic stewardship rituals, especially those backed or orchestrated by the pharmaceutical industry. Doctors are the most enlightened ones on superbug crisis. If they don't realise their own folly, future generations will indeed blame the medical community for the superbug crisis, but for an entire different reason — self-deception!

Seaweed extract shows anti-retroviral activity

The medicinal properties of compounds extracted from seaweed have been used for medicinal purposes. These compounds, as a class called sulphated polysaccharides, have been shown to have anti-inflammatory and antiviral properties. Of interest here is their anti-retroviral activity which makes them potential drugs against HIV.

Bioactive compound

A team from Chennai has extracted one such sulphated polysaccharide known as fucoidan from two seaweed species collected from the Mandapam, Thondi and

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Rameswaram regions along the coast of Tamil Nadu. The team further shows that, in vitro, this compound inhibits the functioning of the HIV-1 strain of the human immunodeficiency virus to a degree that is comparable to the drug tenofovir that is presently in vogue for antiretroviral action. The research was published in Scientific Reports.

Two species of marine brown algae, also known as macroalgae (seaweed), Dictiyotabartaysiana and Turbinariadecurrence were chosen by the team for extraction of the bioactive compound. “We studied many algae species along with these macroalgae and found that these two have more sulphated polysaccharide (fucoidan) than others,” says SanniyasiElumalai Professor and Head, Department of Biotechnology, University of Madras.

Two species

The idea that sulphated polysaccharides can inhibit the activity of viral strains and arrest their growth has been known for some time now. The Chennai group’s effort has been in identifying and extracting such a compound in two species of algae mentioned here that are common and available at low cost.

HIV comes in two strains, HIV-1 and HIV-2, and of these the former strain is more widespread and this is the strain that the group studied. The proliferation of HIV in cells is related to the expression of a protein called gagP24. The bioactive compound extracted from the seaweed and purified was used to treat cell lines (in vitro) and these were compared with two types of control cells. One set of controls were not treated with any chemical, and the second set was treated with tenofovir. The HIV cell lines treated with fucoidan did show a high percentage of inhibition (close to 90%) of the expression of the protein as compared with untreated controls. The drug tenofovir had a high degree of inhibition effect also.

“We are planning to test this macroalgalsulphated polyacrylamide in animal models,” says Prof. Elumalai.

SeeTB: new diagnostic tool for detecting tuberculosis

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Accounting for over a million deaths in 2018, tuberculosis (TB) remains a major healthcare burden for most developing countries, and India still leads the list with the largest number of cases. “The World Health Organization has aimed at eliminating TB by 2035, and the Indian government has vouched to do this by 2025. If this ambitious plan has to succeed, we should be concentrating on not missing out on any case,” says Dr. Sayed E. Hasnain from JamiaHamdard University in New Delhi.

With this aim in mind, he and his collaborators have developed a small device that can be attached to a simple optical microscope to convert it into a fluorescence microscope, thus enabling better TB diagnosis at the point-of-care.

Battery-operated device

Named SeeTB, the device is battery operated and allows quick identification of the bacteria. The team has also developed a clearing reagent called CLR which helps in thinning the collected sputum thus enhancing the bacteria detection. A patent has been filed for both the reagent and the device.

“CLR-SeeTB is a highly economical platform and is most suited for a country like India which has a high TB burden,” adds Dr. Nasreen Z Ehtesham, Director-in-Charge at the Indian Council of Medical Research–National Institute of Pathology and one of the authors of the paper published in Scientific Reports.

“Also, the currently used fluorescence microscopy requires infrastructure, an air-conditioned room, trained professionals and is functional only in tertiary health care centers. SeeTB can be used at the primary health care centres in the villages, and once diagnosed, the treatment can be started.”

The device was used to test more than 300 suspected pulmonary patients. The results showed that compared to fluorescence microscopy, the CLR-SeeTB system had higher sensitivity.

Relative performance

Against bacterial culture studies, fluorescence microscopy showed 63.38% sensitivity while SeeTB system showed improved sensitivity of 76.05%.

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When the performance was compared against GeneXpert, another diagnosis tool that looks for DNA markers of TB bacteria, SeeTB showed improved sensitivity. Also, while GeneXpert method takes about two hours, SeeTB can help find the bacteria in about 30 minutes.

3D printing

Dr. RavikrishnanElangovan from Indian Institute of Technology Delhi and one of the team members explains: "We used 3D printing to rapidly prototype this compact optical platform, and now we are using injection moulding to produce these components in large scale. This can help drastically bring down the cost, thus making it feasible for large scale distributions across the country."

The Indian Council of Medical Research has planned to start large scale validation of the CLR-SeeTB in its primary health research units at different locations in the country.

Infants become susceptible to measles infection earlier than thought

Contrary to the common notion that maternal antibodies against measles protect infants for the first six months of age, a small study involving 25 infants once again shows that antibodies from the mother almost disappear by the end of three months. Hence, infants become susceptible to measles infection at the end of three months and not six months as earlier thought.

Currently, as per the World Health Organization (WHO) recommendation, children in countries like India with ongoing transmission of measles are vaccinated only at 9-12 months of age. In countries with no ongoing transmission, the first dose is administered when the baby is 12-15 months of age. This would mean that babies would remain susceptible to measles infection for a longer period of time before they get vaccinated with the first dose.

The study was carried out on 25 infants in a single tertiary hospital in Toronto, Canada. All the 25 infants had no underlying medical condition and were born at 37 weeks or more of gestation to mothers who were, on average, 32 years old.

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Measles is a highly infectious acute viral illness that can lead to severe complications, such as pneumonia, encephalitis and death. Children younger than five years who get infected with measles have higher rates of complications, hospitalisation and even death.

Antibody levels

The study published in the journal Pediatrics found that of the 25 infants studied, 20% (five of 25) infants had antibodies below the protective threshold even by the end of the first month after birth. And 92% infants had maternal antibodies below the protective threshold by the end of three months. By six months all the babies had antibody levels below the protective threshold.

Based on statistical modelling, the authors found that in Canada the probability of infants getting infected increased with maternal age. This is because pregnant mothers remain protected through vaccination and not through natural infection. They predict that a one-month-old infant has 25% probability of getting infected with measles if the mother is 25 years old but the probability increases to 40% if the mother is 40 years old.

Endemic settings

Babies are considered to be protected against measles through maternal antibodies for the first six months based on studies carried out in measles-endemic settings. In these settings, as in the case of India, many mothers gain immunity through natural infection and are also continually exposed to the virus, leading to “repeated immunologic boosting and more robust antibody levels”. But in countries where measles has been eliminated or is close to elimination, mothers gain immunity through childhood vaccination, which has been associated with lower antibody levels compared with natural infection.

Infants born to mothers in countries where measles virus has been eliminated have lower maternal antibodies and these antibodies quickly fall below the threshold of protection leaving them to susceptible to infection before they receive the first measles vaccination dose, the authors note.

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However, in the case of India, the virus is in circulation and causes many infections each year (there were nearly 72,000 cases in India during October 2018-2019, the third highest in the world). Also, the vaccine coverage with two doses is less than 95% to offer protection to infants who are yet to be vaccinated. Hence, infants in India who are too young to receive the first dose of the vaccine are at greater risk of getting infected.

Best strategies

The authors note that pregnant mothers cannot be administered measles vaccine as the vaccine uses live, weakened virus. According to an Opinion piece published alongside the paper, vaccine-induced protection would be less in infants if the vaccine is given earlier than recommended. Also, early vaccination may "alter response" after the second dose of vaccine, leading to "lower levels of the antibody" compared with children who are vaccinated as per schedule.

"Therefore, the best strategy for protecting infants against measles is adequate community protection delivered through high coverage [over 95%] of two doses of measles-containing vaccine," the authors of the paper write.

Study of one lakh individuals finds why India's children are anaemic

Last month, during the festive season, an ad campaign urged Indian women to invest in iron-rich food and focus on whether they were anaemic. Around the same time, a Lancet Global Health report noted that 23% of Indian men suffered from anaemia. Adding to these findings, now a paper published in Scientific Reports points out that about 58.5% of children below five years of age in India are anaemic.

Factors at play

The team from Havard TH Chan School of Public Health analysed over one lakh children using the National Fertility and Health Survey (2015-16) data. They write that socio-demographic factors including wealth of the family, maternal education, maternal age, type of residence are the main reasons behind the incidence of

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childhood anaemia.

"Maternal education plays a very important role in reducing the incidence of childhood anaemia in any society and indeed in India. It increases the chances of mothers appreciating the issues involved and taking the correct and appropriate steps towards preventing it. Our study revealed an inverse relationship between the mother's education and incidence of childhood anaemia, in India.

In other words, as the mother's education level increases, the tendency of the child to be anaemic decreases significantly," explains NkechiOnyeneho in an email to The Hindu. She is the first and corresponding author of the paper published in Scientific Reports.

The report notes that even the richest households had anaemic children. While 52.9% of children in the rich households were marked anaemic, the number was 63.2% in the poorest households. Overall, vitamin A and iron intake was also lower than the recommended level.

Meaningful intervention

Dr. Onyeneho explains that nutritional and iron deficiencies top the list of factors that predispose children to anaemia in India and these should be prioritised in any intervention. "From our previous study of intergenerational anaemia, we observed that in addition to maternal influence on childhood anaemia, paternal and overall household influences must be considered for a more comprehensive policy framework for intervention at the household level," she adds.

Premature delivery

Previous studies from across the globe have shown that severe anaemia in mothers and premature delivery can also lead to childhood anaemia and so the mother's health needs to be addressed as well.

Dr. Onyeneho says that the most shocking find for her was the inverse relationship between the age of mothers and the incidence of anaemia in children. The study showed that children of younger mothers are more anaemic. "While one may understand the powerlessness of mothers 15-19 years [old] in ensuring the children

get the right food. It also reveals the power dimension in the household allocation and use of resources." The team has now planned to study gender power relations in household and how it influences childhood anaemia in India.

The paper notes that though India has an anaemia control programme which recommends iron intake and folic acid supplements, the results show that the programme has not been a success.

The researchers urge immediate work be carried out to bridge the gap between policy and practice. They also call for a broader health strategy, to effectively address this issue.

Combination therapy using malaria drug quickly clears TB

Researchers from Bengaluru have made an important discovery of the mechanism used by TB bacteria to tolerate TB drugs, which necessitates longer treatment of six-nine months. They have also demonstrated that a drug combination that prevents the bacteria from inducing this mechanism leads to almost complete clearance of the bacteria from the mice lungs in just two months of therapy. If further studies and trials show similar results, a shorter treatment regimen might be sufficient to treat drug-sensitive TB.

The common notion is that only the non-replicating or slowly metabolising TB bacteria become tolerant to anti-TB drugs. But the team led by Amit Singh from the Department of Microbiology and Cell Biology, and Centre for Infectious Disease Research at the Indian Institute of Science (IISc) found a fraction of the bacteria inside the macrophages was able to tolerate anti-TB drugs even when actively multiplying.

The researchers found that using an already approved anti-malaria drug chloroquine in combination with a TB drug isoniazid can almost clear all the bacteria from the lungs of mice and guinea pigs in just eight weeks. In addition, the drug combination also reduces the chances of TB relapse. The results were published in the journal Science Translational Medicine.

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Reducing the pH to make it acidic is the first-line of defence by macrophages when infected with pathogens. But the researchers found that instead of controlling the TB bacteria, the mildly acidic pH was actually facilitating a fraction of the bacteria to continue multiplying and develop drug tolerance.

Counter oxidative stress

"We used a biosensor which we had developed a few years ago to see the amount of oxidative stress inside the TB bacteria during infection. We found that anti-TB drugs induce oxidative stress to kill bacteria inside macrophages. However, the drug tolerant bacteria have a remarkable ability to counter oxidative stress," says Prof. Singh. "The bacteria used the acidic pH of macrophages as a cue to specifically increase its capacity to deal with oxidative stress." Also, the drug-tolerant bacteria induce efflux pumps to expel antibiotics as an additional mechanism to reduce antibiotic efficacy.

The drug-tolerant bacteria were found in macrophages that were more acidic (pH 5.8) while the drug-sensitive bacteria were seen in macrophages that were less acidic (pH 6.6).

"We hypothesised that reverting the pH within macrophages to its normal state could probably make the bacteria sensitive to antibiotics," Prof. Singh says. "The chloroquine drug does just that — it neutralises the pH within the macrophages. This prevented the bacteria from inducing the mechanism to protect themselves from oxidative stress. So no drug-tolerant TB bacteria emerged." Once the pH is neutralised, the isoniazid drug was able to eradicate TB from animals.

While the two-month treatment was able to completely sterilise mouse lungs, a near-complete eradication was observed from the lungs of guinea pigs. "The combination was shown to reduce TB bacteria load in both mice and guinea pigs," says Richa Mishra from IISc and the first author of the paper.

Many times effective

In the case of in vitro studies using cell lines and mice macrophages, the ability of the combination drug therapy to reduce TB load was found to be three- to fivefold higher

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than when treated only with TB drugs. “Reduction in bacteria load was more when we combined chloroquine with isoniazid,” says Mishra. “We observed threefold reduction when we combined chloroquine with rifampicin and fivefold reduction when we used chloroquine-isoniazid combination.”

To determine TB relapse following treatment, mice infected with TB were completely rid of bacteria using the drug combination. Eight weeks later, the immune system of mice was suppressed using a drug. While all the five mice treated with only isoniazid relapsed with high bacterial load, three of the five mice treated with the combination drug showed very little presence of bacteria. “This shows that the drug combination reduces the chances of TB relapse,” says Mishra.

The work was carried out in collaboration with researchers from Bengaluru’s National Centre for Biological Sciences and Foundation for Neglected Disease Research.

A typhoid vaccine manufactured in India offers 82% protection

A typhoid vaccine (Typbar TCV) developed by the Hyderabad-based Bharat Biotech has shown 81.6% efficacy in preventing typhoid fever at 12 months in a phase-3 clinical trial. The trial was carried out in Nepal in over 10,000 children who received the vaccine.

A single dose of the vaccine was found to be effective in preventing typhoid in children aged nine months to 16 years. The vaccine confers protection two–three weeks after vaccination. The duration of protection is currently not known. The results of the trial were published in The New England Journal of Medicine (NEJM). The Typbar TCV vaccine was recommended by WHO’s Strategic Advisory Group of Experts on Immunization (WHO-SAGE) in December 2017. The WHO prequalified the vaccine in January 2018.

Typhoid fever is caused by highly contagious Salmonella Typhi bacteria. Nearly 11 million fall sick due to typhoid and about 1,17,000 deaths are reported each year. The bacteria spread through contaminated food and water.

Key advantages

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The Typbar TCV typhoid vaccine tested in Nepal is a conjugate vaccine. A conjugate vaccine is one in which the antigen (which is a polysaccharide in this case) is chemically linked to a carrier protein.

Two other typhoid vaccines — polysaccharide typhoid vaccine and live, weakened typhoid vaccine — are already used commercially. But the efficacy of these vaccines to protect against typhoid is lower than the conjugate vaccine that has now been tested in Nepal.

"The other two vaccines offer 60-70% protection unlike the conjugate vaccine which confers nearly 82% protection. Two doses of live, weakened typhoid vaccine are needed to reach 60-70% protection," says V. Krishna Mohan, Executive Director at Bharat Biotech. "More importantly, the conjugate vaccine can be given to babies as young as six months, while the other two vaccines cannot be given to children below two years of age." According to SAGE, in high-incidence settings, a large proportion of severe typhoid fever cases occur in children aged below two years.

While typhoid bacteria can be treated with antibiotics, the microbes have developed resistance against multiple antibiotics. Multidrug-resistant typhoid bacteria are seen in south Asia including India. Since 2016, extensively drug-resistant (XDR) typhoid outbreaks have been reported from Sindh province in Pakistan. According to an editorial accompanying the paper, XDR typhoid has been found in India, Bangladesh, and Pakistan.

Earlier trials

Earlier, a small phase-3 trial carried out in India by Bharat Biotech and University of Maryland School of Medicine, Baltimore, in two groups — 2-45 years old and 6-23 months old — found that a single dose of the vaccine was able to provoke immune response in 98% of the vaccinated children. The results were published in the journal Clinical Infectious Diseases.

A phase-2b human challenge trial was carried out in adult healthy volunteers aged 18-60 years who are typhoid naïve (no history of typhoid infection or vaccination). The volunteers were first vaccinated and then exposed to the bacteria to assess the

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ability of the vaccine to prevent infection. The results published in December 2017 in The Lancet showed that the vaccine has 88% efficacy in preventing an infection.

Exported to Pakistan

The vaccine has already been licensed in India and is available for clinical use. The company has been supplying the typhoid conjugate vaccine to Pakistan since 2017. "So far about 10 million vaccines have been supplied to Pakistan," says Dr. Mohan. Pakistan is the first country to introduce the typhoid conjugate vaccine as part of its national immunisationprogramme.

2.3 million Children in India unvaccinated for measles

In 2018, measles caused an estimated 10 million cases and 1,42,000 deaths globally, according to a report published on December 6. The estimated cases and deaths are much more than what countries have reported to the World Health Organization and UNICEF. The number of measles cases reported in 2018 was only 3,53,000.

Preventable condition

Measles can be prevented through two doses of vaccination. But the number of children who are not vaccinated against measles is alarmingly high in six countries. At 2.3 million, India has the second highest number of children who are not vaccinated against measles, the report published in Morbidity and Mortality Weekly Report (MMWR) says. With 2.4 million, Nigeria has the most number of unvaccinated children. The other four countries with the most number of unvaccinated children are Pakistan (1.4 million), Ethiopia (1.3 million), Indonesia (1.2 million) and the Philippines (0.7 million).

In 2017, 2.9 million children in India under one year of age had not been vaccinated with the first dose, according to UNICEF. In one year, the number of unvaccinated children in India had reduced from 2.9 million to 2.3 million. The corresponding reduction in the case of Nigeria has been much more — from nearly 4 million unvaccinated children in 2017 to 2.4 million in 2018.

There were nearly 70,000 cases of measles in India in 2018, the third highest in the

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world. In 2019, over 29,000 confirmed cases have been reported to the WHO.

The WHO recommends 95% coverage using two doses of measles vaccine to prevent outbreaks. Though vaccine coverage with first and second dose has increased globally since 2000, it has not reached anywhere near 95%. In 2018, only 86% of children globally received the first dose through routine immunisation. In the case of second dose, the coverage globally is just 69%.

Failing to immunise

In India, the first dose of measles vaccine is given at nine-12 months of age and the second dose is given at 16-24 months of age through the national immunisationprogramme. But it appears that millions of children in India do not receive measles vaccine through routine immunisation activities.

According to the MMWR report, in 2018, 19.2 million children globally worldwide did not receive the first dose through routine immunisation services. Nearly 163 million children in India received the measles vaccination during mass immunisation campaigns. India accounted for 47% of the 346 million children across the world who received measles vaccine during mass-immunisation campaigns.

Effective strategy

Mass immunisation campaigns are an effective strategy for delivering vaccination to children who have otherwise been missed by routine services. But it does reflect how many children get missed by the routine immunisationprogramme.

The first dose of measles vaccine was introduced as part of the national immunisationprogramme in the 1990s. Based on the WHO's recommendation to administer a second dose to prevent infection and death in 90-95% of vaccinated children, India introduced the second dose from 2010 onwards. India was one of the last countries to add a second dose of measles vaccine as recommended by the WHO.

The first mass immunisation campaigns for the second dose of measles vaccine were launched in 2010 in 14 States where the coverage for the first dose was below 80%. The campaign targeted children aged nine months to 10 years of age.

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Coffee is a health drink, but do not overdo it

It is well known that black tea (that we Indians drink) is a health drink. A concise summary by Dr. A. Enloe on its ten major benefit appears in Heathline, May 16, 2018 issue. A similar analysis on coffee as a health drink appears in the November 28, 2019 issue of Specialty Medical Dialogues, Dr. HinaZahid writes: “Coffee is arguably one of the most studied components of our diet, with an extensive range of research published in areas of mental performance, sports performance, fluid balance, type 2 diabetes, liver function, neurodegenerative disorders, pregnancy, cancer, and cardiovascular disease (CVD). Metabolic syndrome is a condition which is estimated to affect more than one billion people across the globe and it increases the risk of cardiovascular problems, including coronary heart disease and stroke. A report from the Institute for Scientific Information on Coffee (ISIC) highlights the potential role of coffee consumption in reducing the risk of developing metabolic syndrome and states:“The new report of meta-analysis has suggested that drinking 1-4 cups of coffee per day is associated with a reduced risk of metabolic syndrome in observational studies.”

A meta-analysis combines the results of many scientific studies addressing the same question, analyses the result of all these, identifies how well they lead to the same conclusion, and to what level they may differ from one another. It thus offers a more robust summary of the main conclusion and the acceptable “take home message”. Dr. GuiseppeGrosso and colleagues of the Catania University, Italy conclude that coffee consumption reduces the risk of type 2 diabetes, hypertension and so forth (see Grosso et al;. Annual Review of Nutrition 2017, 37; 131-156). Another meta-analysis by Navarro et al; Clinical Nutrition 2019 Feb.,38 (1): 389-397 shows that regular consumption of coffee helps in reducing the risk of hypertension.

People who are interested in finding out more about coffee and health may visit http://www.coffeeandhealth.org, which offers a detailed analysis on the benefits of coffee on health. These all suggest that coffee is a health drink, but in small amounts (3-5 cups day) Drinking too much of it is also bad. Mayo Clinic advises that going

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beyond this is an overdose, and that the increased caffeine levels lead to migraine headache, insomnia, restlessness, muscle tremors, and fast heartbeats. It is thus wise to limit the cups. Also, it should not be given to children. Pregnant mothers may further restrict their cups.

Arrival in India

Coffee, originally Ethiopian in origin, was quickly taken over and held tight by the Arabs as their own drink (since wine was prohibited) that alerts the imams and the believers. The "Insight" column of http://madrascouriers.com of June 19, 2017 states that the 16th century Sufi saint Baba Budan smuggled several seeds of it from the Arab monopoly, and planted them in Chikkamagalur of the Mysore kingdom in 1670. Although, it might have been brought to the Malabar Coast earlier by Arab traders. It is thus that coffee was planted and grown in Karnataka, Kerala and Tamilnadu. Recently, it is also grown in the Araku Valley of Andhra Pradesh and more recently in some of the 'seven sisters' states of northeast India , And this also appears how coffee drinking seems to have become a popular daily drink in Peninsular India since centuries.

But then most south Indians drink not pure coffee, but a mixture of coffee and chicory. Chicory, a native plant, is cultivated and grown the in the Mediterranean regions of Spain, Greece, and Turkey. It became popular in Europe both on its own and as an addition to coffee. The site "Bynemara Tales-Medium" points out in its 19-7-2017 issue that France started using it due to the shortage of coffee there in the early 1880s. Since then the coffee-chicory duo became popular. The English writer Charles Dickens (of 'David Copperfield' and 'A Tale of Two Cities' fame) is said to have written: "By the combination of a little chicory with coffee, the flavour of the coffee is not destroyed, but there is added to the infusion a richness of flavour, and a depth of colour - a body- which renders it to very many people much more than welcome as a beverage". And that the colonial British played a key role by introducing what they called as "camp coffee", a secret blend of water, sugar, 4 % caffeine-free coffee essence and 26% chicory essence. And Indian soldiers and

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people at large warmed up to it. Over time, South Indian coffee has come to mean a mixture of coffee and chicory in varied ratios, anywhere from 80% coffee and 20% chicory powder to the more common 60-40 ratio. We also cultivate chicory in India - in Gujarat and UP, where the soil and the climate suits it best.

Going beyond south India

Traditionally, the South Indian Coffee confined itself to the four southern states, while tea was more popular and widely drunk almost exclusively in the North, since they produced, harvested and marketed the tea plant and its leaves in Assam, West Bengal and some of the northeastern states, where the climatic and soil conditions suit the plant best. But in recent times, more 'Southies' have also taken to tea, not as an alternative, but additionally. And the 'Northies' to coffee, again additionally. A major reason behind this has been marketing. Even here, apart from 'filter coffee', we now have other genre such as espresso, cappuccino, and such Western introductions, particularly among the city dwellers. What used to be 'chai pecharcha', where all kinds of debates, discussions and meeting (or not) of minds, and new political ideas used to occur over tea, which Satyajit Ray epitomised in his film Agantuk, we have now added coffee shops (with free wi-fi connectivity) which are advertised as "a lot can happen over coffee". But they are not the same as the addas of yesteryears.

'How body becomes prone to rotavirus infection decoded'

Researchers have discovered how a brief disruption in the guts of pre-born mice can compromise their adult immunity to rotavirus infection. The study, published in Science Immunology showed that this prevented a robust antibody response in adult mice to rotavirus. This early disruption limits the ability of the immune system to later trigger and generate production of Immunoglobulin A (IgA) antibodies.

Biomarkers for glioma brain tumour found in peripheral blood

Researchers have found potential gene biomarkers that can be used for prognosis and early diagnosis of the most aggressive form of primary brain tumour called

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glioblastoma. The biomarkers can help in knowing if the tumour is at an initial stage (low-grade) or advanced stage (high-grade).

The multi-institutional research work carried out by a team led by Javed N. Agrewala from Institute of Microbial Technology (CSIR-IMTECH), Chandigarh, now at IIT Ropar, looked at immune cells called macrophages in the tumour microenvironment to understand their role in suppressing or boosting the immune system to keep the tumour under check. The role of certain macrophages in suppressing the immune system leading to progression of cancers such as breast, prostate, bladder and cervical cancers is already known.

Two macrophages

Based on patient tissue samples the researchers identified two macrophages — M1 and M2 — that were associated with the tumour. These were identified using hallmark gene markers (CCL3 gene for M1 macrophage and CD163 for M2 macrophage). The M1 macrophage is protective for glioma while the M2 macrophage is not. The M2 macrophage control the immune response and intimately interacts with the tumour and supports tumour progression.

“We observed that as the glioma progresses from low-grade to high-grade, the amount of M1 macrophages reduced and the amount of M2 macrophages increased,” says Prof. Agrewala. “Thus the ratio of M2 macrophage marker CD163 versus M1 macrophage marker CCL3 can ascertain the glioma progression.”

Making a prognosis

In the low-grade glioma, the ratio of M2/M1 macrophages (or CD163/CCL3) is less while it is high in the case of high-grade gliomatumour.

“Besides indicating whether the tumour is low- or high-grade, the macrophages can also indicate the chances of survival of patients with glioma,” says AurobindVidyarthi from CSIR-IMTECH, the first author of a paper published in Cancer Immunology, Immunotherapy. He is currently a post-doc at Yale University, New Haven, U.S. “In low-grade glioma patients we see both M1 and M2 macrophages. But if there are more M2 macrophages (as indicated by the gene marker expression) than M1

macrophages, the survival is less. Likewise if there are more M1 macrophages then the patient has better chances of survival."

Most studies have looked at only the local immune response in the tumour region. But these researchers went a step ahead and looked for macrophage phenotypes and different T cells in peripheral blood samples collected from glioma patients.

Markers in blood

"Interestingly, compared with healthy individuals, there was elevated level of M2 macrophages in peripheral blood too. This indicates that the influence of glioma is so prominent that M2 macrophages can be found in the blood," says Dr. Vidyarthi. Besides M2 macrophages, the researchers also found in the blood PD-1 expressing CD4 T cells. During chronic infection and tumour, the T cells become exhausted. "So instead of promoting, the exhausted CD4 T cells end up suppressing the immune system at the systemic level. Consequently, both CD4 T cells and M2 macrophages suppress the immune system at the systemic level," says Prof. Agrewala. "Thus the gene biomarkers in blood samples can be used for early diagnosis and prognosis of the gliomas. We need to carry out studies on more samples before being certain."

Researchers from Postgraduate Institute of Medical Education and Research, Chandigarh were also a part of the study.

Need a different approach to address child malnutrition

Globally over 200 million children below five years of age are chronically malnourished causing persistent problem in middle- and low-income countries. Though India's National Family Health Surveys (NFHS) show that there has been a decline in child malnutrition numbers in the country, various studies show that the rate of decline is very slow, and India is still fighting a tough battle.

District level trends

Now, a team from Harvard and Cambridge University has assessed district-level trends in the prevalence of malnutrition and how wealth disparity plays a role in five important malnutrition indicators such as stunting, underweight, wasting, low birth

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weight, and anaemia. The researchers analysed the NFHS-4 data of 2015-16 and noted that among the four indicators, anaemia was highly prevalent at 54.6%, across the poorest of the poor in Rajasthan, Gujarat, Madhya Pradesh and Telangana.

The team also placed each district under four categories — disparity, pitfall, intensity or prosperity — based on the overall burden and wealth disparity.

Wealth disparities in underweight children were seen across all districts with Gujarat, Jharkhand and Bihar having the worst disparities and Mizoram, Nagaland and Manipur having the least. “Underweight is highly correlated with child morbidity and is reflective of the current environmental and nutritional status of the child. Hence, underweight is arguably a more relevant and straightforward indicator to monitor for progress in child malnutrition,” explains Dr. Rockli Kim from the Harvard Center for Population and Development Studies, U.S. in an email to The Hindu. She is the corresponding author of the paper recently published in SSM- Population Health.

The paper adds that for stunting and underweight, the north and central region of India which includes Uttar Pradesh, Bihar and Jharkhand were composed primarily of “pitfall” and “intensity” districts.

The team explains that though the Government of India’s new initiative National Nutrition Mission (NNM) has led to a progressive decline in child malnutrition, the decline has been slow and the improvements have not been equally distributed across the population. “Our work provides estimates to inform policies and interventions to target areas with the highest overall burden and the worst wealth disparity in child nutritional status. Even within well-performing districts, there can be gross in egalitarian malnutrition outcomes,” explains S.V. Subramanian from the Department of Population Health and Geography at Harvard University in an email to The Hindu. He is one of the authors of the paper.

Different strategies

“Districts where the prevalence of malnutrition is uniformly high likely require a different intervention strategy compared with districts where prevalence is high but

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disproportionately shouldered amongst poorer households within the district. It is important to make sure progress on child nutrition is made both effectively and equitably," he adds.

Biotechnology

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IGIB finds a protein with better precision in gene-editing

Researchers at the Delhi-based Institute of Genomics and Integrative Biology (CSIR-IGIB) have discovered a protein variant from a different species of bacteria that can edit the DNA with very high precision. In the tool now commonly used for editing disease-causing mutations in DNA (CRISPR-Cas9), the Cas9 protein behaves like a molecular scissors that cuts the DNA at a specific location and inserts a foreign piece of DNA to correct the mutation that causes the disease.

In addition to binding to the intended target on the DNA, the commonly used Cas9 protein from Strepotococcuspyogenes bacteria (SpCas9) and its engineered derivative tend to potentially bind to DNA at multiple unintended sites thereby leading to unnecessary alterations in the DNA.

The researchers found their new Cas9 protein, which binds and cuts the DNA, was able to correct sickle cell anaemia mutation in patient-derived stem cells. The protein (FnCas9) used by the researchers to edit the DNA is derived from a bacterium — Francisellanovicida.

The Cas9 protein is supposed to bind to the DNA only when there is a perfect match between the DNA and the protein, thus reducing the chances of the protein binding at non-target sites on the DNA. But even when three mismatches exist between the protein and the DNA, the currently used SpCas9 protein binds and cleaves the DNA. In contrast, the team led by DebojyotiChakraborty from IGIB found the new FnCas9 protein showed negligible binding when there exists more than one mismatch in the target DNA. The results were published in the journal Proceedings of the National Academy of Sciences (PNAS).

High specificity

“The high specificity of the new FnCas9 protein arises due to reduced affinity to bind to DNA when there is even a single mismatch. And when there is more than one mismatch, complete absence of binding of the protein to the DNA is seen in many cases,” says Dr. Chakraborty.

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"If the Cas9 protein remains bound to DNA at mismatched locations for a long time, there is a possibility that it might cut the DNA at these locations. Also, if it remains bound to DNA, the protein might block the transcription (which is the first step in gene expression) at that location. And if Cas9 is bound at multiple unintended sites then the transcription machinery gets stalled and the expression of genes at these locations might be altered," Dr. Chakraborty explains.

In nature, DNA often gets damaged and is routinely repaired through one of the two pathways. In the case of the homology-directed repair (HDR) pathway, which is relatively less error-prone, matching sequences are used to repair the DNA. "The FnCas9 protein was found to increase the HDR repair rate fourfold compared to the widely used SpCas9," says Deepanjan Paul from CSIR-IGIB and one of the first authors of the paper.

Sickle cell anaemia

The researchers tested the precision of binding and cleavage at the desired sites on the DNA using mouse cell lines (embryonic stem cells and brain cells), human kidney cell lines and induced pluripotent stem cells (iPSc). In the case of human iPS cells, the FnCas9 protein was found to bind to the DNA at the specific site, cut and repair the sickle cell anaemia mutation.

"The correction process is the same for any disease-causing mutation and so our FnCas9 protein should theoretically correct any mutation in the DNA. The efficiency might vary, so we must test it for each disorder," says Dr. Chakraborty.

The efficiency of any Cas9 protein delivery as well the ability to correct mutations is generally low in the case of iPS cells. The efficiency of correction is about 1.6%. Though the efficiency to correct mutations is low in iPS cells, the corrected cells can be isolated, multiplied and converted (differentiated) into haematopoietic stem cells. Once differentiated into haematopoietic stem cells, they can be transfused into patients.

"Differentiating iPS cells into haematopoietic stem cells is not trivial. Plenty of experimental work is under way to make it efficient for clinical translation," says Dr.

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Chakraborty.

Recalling how he started working on FnCas9 protein for genome editing, Dr. Chakraborty recalls that he was looking for a Cas9 protein which can target RNA instead of DNA. There was one study that reported that FnCas9 could potentially target viral RNA. “We were not able to target RNA using FnCas9 proteins. So we started to investigate whether it can target DNA as well since it was not known if FnCas9 can be used for precise gene correction. We found that not only does it target the DNA but does so with very high specificity,” he says.

“We are now proceeding for preclinical studies to establish the efficacy of FnCas9 protein for genome-wide binding and targeting using patient-derived cells and mouse models,” he says.

Druggable targets found for S. aureus

Novel protein targets that can be used by candidate drug molecules to kill antibiotic-resistant strains of Staphylococcus aureus, including vancomycin-resistant S. aureus, have been identified by researchers at the Indian Institute of Science Education and Research (IISER) Pune.

The protein targets identified are crucial for the growth and survival of the bacteria, and hence S. aureus are less likely to cause mutations in them to confer drug-resistance. Any drug candidate that can bind to the targets will be able to inhibit the protein from functioning leading to eventual death of S. aureus, including the drug-resistant ones.

The researchers used a small molecule (quinone epoxide) and attached an indole residue to it to increase the ability of the molecule to cross the cell barrier of the bacteria and bind to the proteins. “Many small molecules lack the ability to cross the cell barrier. By making the small molecular permeable, it became possible to know which proteins are crucial for bacterium’s survival,” says HarinathChakrapani from the Department of Chemistry at IISER Pune, one of the corresponding authors of a paper published in Journal of Medicinal Chemistry.

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The small molecule bound to multiple proteins, including a few that are crucial for growth and survival of the bacteria. These proteins are crucial as they bind to the DNA activate it for normal cellular functioning.

The small molecule was found to bind to a particular amino acid (cysteine) that is very important for many catalytic functions in the cell. So inhibiting the functioning of this amino acid (cysteine) can have a cascading effect leading to death of the bacteria.

The small molecule was found to be very specific to S. aureus and was highly potent in cell culture studies. “But in animal studies the molecule did not appear to be as potent. Nevertheless, it’s a good starting point to eventually develop an antibiotic that is effective even against the multidrug-resistant bacteria,” says Dr. Siddhesh S. Kamat from the Department of Biology at IISER Pune and another corresponding author of the paper. “Now that we have a new small molecule that can cross the cell barrier, bind to proteins and kill the bacteria, we can always decorate the molecule with functional groups and make it more bioavailable in animals.”

BIO-TECHNOLOGY

IIT Jodhpur fabricates highly sensitive device to detect lead

A highly sensitive, portable device that can detect the presence of lead in water even when present in extremely small amount of 0.018 parts per billion (ppb) has been fabricated by a team of researchers from the Indian Institute of Technology (IIT) Jodhpur. The World Health Organisation limit for lead in drinking water is 5 ppb.

Besides being highly sensitive, the sensor is also highly specific to lead even in the presence of other metals such as mercury, copper, zinc, cadmium and chromium. It takes just about four seconds to detect lead.

“The sensor can be reused multiple times. We tested it for 50 cycles but as the materials used in the sensor are stable, it can be used several times for real-time monitoring,” says Prof. Mahesh Kumar from the Department of Electrical Engineering at IIT Jodhpur who led the team. Theresults were publishedin the journal IEEE Electron Device Letters .

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The research was done in collaboration with the Singapore-based Agency for Science, Technology and Research.

Fabricating the sensor

The sensor is fabricated using silicon wafer as the base material. However, the crystal structure of silica and gallium nitride/aluminium gallium nitride is different and so they experience stress when grown on silicon. “Also, the thermal expansion of silicon and gallium nitride is different. As the layers are grown at 1,000 degree C, it causes stress on the grown material,” says Prof. Kumar.

To produce a layer of gallium nitride that is stress-free, the researchers produced a stack of five layers of gallium nitride and aluminium gallium nitride on the silicon wafer base (with the percentage of aluminium in gallium nitride reducing from 100% to 0%). This helped in producing an almost defect-free gallium nitride layer at the top. A layer of AlGaN is then grown on the defect-free gallium nitride.

The researchers then fabricated the source and drain terminals that allow the electrons to flow and then used a gate (akin to a valve) to regulate the flow of electrons.“At the junction of the top layers of GaN and AlGaN, a two-dimensional electron gas is formed naturally, which is the conducting layer that moves the electrons from the source to the drain,” he explains.

Finally, the gate was functionalised to facilitate lead ion adsorption. When lead ions get adsorbed on the gate, the rate of flow of electrons increases leading to increased current flow. The amount of increase in current depends on the amount of lead ions that get adsorbed.

“There is a slight increase in current even when lead concentration in water is as low as 0.01 ppb. The increase is more at higher lead concentration,” says Adarsh Nigam from IIT Jodhpur and the first author of the paper. “We used 0.5 volt to ensure a constant flow of current from the drain to the source.”

“We tested the sensor using 15 samples each of tap and lake water. The sensor shows good agreement with the results from standard techniques used for lead detection,” says Nigam.

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The sensor can be reused by washing with water. The sensor response time — the time taken to detect lead — is hardly affected when reused, Nigam says.

Developing more sensors

"We are fabricating an array of devices on a single chip to detect different heavy metal ions. We have already developed a cadmium ion sensor," says Nigam. "The cadmium sensor has higher sensitivity (0.255 ppb) than other electrochemical approaches and can detect cadmium in about 3 seconds." The results of cadmium sensor werepublished in April 2019in the journal IEEE Electron Device Letters.

IIT Bombay's sensor detects zinc in sweat, soil in real-time

A highly sensitive sensor that can detect real-time the presence of zinc over a wide concentration range — 0.1-500 ppm — has been fabricated by researchers at the Indian Institute of Technology (IIT) Bombay. The electrochemical sensor can be used for detecting zinc in the soil even in the presence of other elements and also at minute levels as seen in human sweat.

Accurate determination of zinc in soil samples will help in soil-nutrient assessment and prevent overuse of fertilisers while measuring zinc in sweat samples can help signal early onset of muscular fatigue. It can be used as a noninvasive point-of-care sensor. Further, the sensor requires only few microliters of analyte, thus making it possible to detect zinc in sweat samples.

Mechanically sturdy

The sensor is mechanically sturdy and so the signal response remains unaffected even when the sensor is bent 180 degrees. The sensor can also be employed over 4-7 pH range, indicating its usefulness for both sweat-based physiological sensing and soil-nutrient assessment.

The two-member team led by Prof. ChandramouliSubramaniam from the Department of Chemistry at IIT Bombay have already tested the sensor for the presence of zinc on sweat samples and in three different soil samples — deep black soil, read loamy soil and red clayey soil — collected from Maharashtra, Rajasthan and Tamil Nadu.

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The sensor has one working electrode and a reference electrode. These electrodes are made of cellulose fibre coated with carbon nanotubes. The working electrode is coated with a polymeric ion-receptor (tetrakisaminophenylporphyrin) that binds specifically to zinc.

A fixed voltage is applied to the electrodes and there is an increase in current when zinc binds to the porphyrin receptor on carbon nanotubes. The amount of increase in current depends on the concentration of zinc that binds to the electrode.

"We are able to detect extremely low concentration (0.1 ppm) of zinc because of the very high surface area and electrical conductivity of carbon nanotubes," says SudeshnaMondal from IIT Bombay and first author of apaperpublishedin the journal ACS Sustainable Chemistry &Engineering.

The porphyrin receptor in mixed with polyvinyl chloride (PVC) and then coated on carbon nanotubes. "Using the PVC matrix ensures uniformity in terms of porphyrin coverage on carbon nanotubes. If we directly coat the carbon nanotubes with porphyrin receptor, we cannot control the uniformity and number density of porphyrin," says Prof. Subramaniam.

Both the electrodes were then laminated. "We sealed the electrodes by laminating it and provided a well-defined opening in the middle of the lamination to allow direct interaction between porphyrin and zinc," says Mondal.

Explaining the rationale behind lamination, Prof. Subramaniam says: "A fixed-size opening controls the area of interaction as well as achieves uniformity of interaction between zinc and porphyrin. The signal from the sensor depends on the area of contact with zinc."

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Perfect match

The porphyrin receptor has a cage-like structure with a void in the centre. "The size and charge of the void matches perfectly with zinc. The matching size makes it possible for zinc to bind to porphyrin and the charge allows the interaction between the two," he says. "It is akin to only iron binding to porphyrin in haemoglobin." The researchers are working on developing a read-out device to use the sensor in

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collaboration with Electrical Engineering Department at IIT Bombay. Meanwhile, field trials are under way to further test the device. “In six months we will be able to make a full-fledged product,” Prof. Subramaniam says. “This project is funded by the Nanomission program of DST India and is intended to complement the soil-health card program of the Indian government.”

The researchers are already working on developing similar sensors for other plant nutrients such as potassium, nitride, phosphate and sodium.

“We already know which ion-receptor to use on carbon nanotubes to achieve perfect binding with each analyte,” he says.

Now, machine learning-based model can determine if skin cancer has spread

Using the expression of 17 key genes (messenger RNAs) it is now possible to distinguish primary and metastatic cutaneous melanoma, which is the most common type of skin cancer. While 11 of the 17 genes have already been reported by other studies for cutaneous melanoma, it is for the first time that the potential role of remaining six genomic signatures in classifying samples as either primary or metastatic skin cutaneous cancer has been made.

The 17 genomic signatures, which were identified by a team led by Prof. Gajendra P.S. Raghava from the Indraprastha Institute of Information Technology (IIIT), New Delhi, have high accuracy — over 89% — in discriminating metastatic from primary skin melanoma. These signatures also have high sensitivity (in case tumour is metastatic), and high specificity (in case the tumour is primary). The results were published in the journal Scientific Reports.

Unlike in the case of primary skin melanoma, people with metastatic cutaneous melanoma have reduced survival rate and higher mortality rates. It therefore becomes important to be able to identify and classify skin cutaneous melanoma as either primary or metastatic so correct therapeutic strategies can be chalked out and survival rates improved in patients.

Messenger RNA

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Six machine learning models were used to study and validate the genomic signatures. They used expression profile of messenger RNA, micro RNA and methylation profile for discriminating tumour as primary or metastatic. “We found the messenger RNA expression profile was the strongest predictor of metastasis. The mRNA expression profile performed better than micro RNA and methylation profile of the patients,” says Harpreet Kaur from Institute of Microbial Technology (CSIR-IMTECH), Chandigarh and one of the first authors of the paper. “Of the six models used, one (SVC-W) model showed better ability to discriminate metastatic from primary tumours of validation dataset with overall accuracy of over 89%.”

While messenger RNA outperformed microRNA in discriminating the status of the tumour, a particular microRNA was found to be a “strong predictor of metastatic melanoma”.

Besides helping in distinguishing the kind of melanoma, the genomic signatures can also help in further categorising different stages of metastasis. For instance, it can tell if the tumour has spread to lymphatic nodes, which is an early stage of metastasis. Also, it can tell if the cancer has spread to distant parts of the body, which is a late stage of metastasis, says Dr. Sherry Bhalla from IIIT Delhi and the other first author.

Six machine learning models were tested and used for classifying the tumour as either primary or metastatic. Of the six models, one model — Support Vector Classification with Weight (SVC-W) — has an accuracy of nearly 89.5%.

The researchers have fiurtherntegrated the major prediction models in the webserver called CancerSPP that will help clinicians in classifying cutaneous melanoma as primary or metastatic using RNA sequence data, microRNA and methylation expression data. “It will also help in knowing the different states of metastatic samples,” says Kaur. “The analysis module in the CancerSPP webserver will provide information on the role of each of the important genes in various stages of metastasis and whether the expression of a gene is up-regulated or down-regulated.”

IISc: Natural shield protects certain DNA regions from radiation damage

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It is well known that ionizing radiation can break the double-stranded DNA in one or both the strands. Now a study by researchers at the Indian Institute of Science (IISc) Bengaluru have shown that regions of the genome rich in four-stranded DNA made of guanine nucleotide base — G-quadruplexes (G4-DNA) — are more resistant to irradiation. As a result, there are fewer DNA breaks seen in G-quadruplexes when exposed to radiation. The lower sensitivity to radiation was seen in studies carried out in vitro and inside cells.

The team led by SatheesRaghavan from the Department of Biochemistry at IISc found that contrary to the general notion that radiation-induced DNA breaks are random in nature and can occur throughout the genome, the breaks are sequence-dependent. Certain regions of the genome were found to be resistant to radiation with fewer strand breaks in the DNA, and these regions are rich in G-quadruplexes.

G-quadruplexes typically consist of three-guanine nucleotide base found together and repeated four times. When a guanine nucleotide gets repeated it tends to fold itself into a four-stranded DNA. There are 3.5 to 7 lakh G-quadruplexes in the human genome, and these are found in certain regions of the genome such as the telomeres that act as caps on either end of the chromosomes.

“When we exposed double-stranded DNA to radiation, the DNA was getting cut randomly. But those regions of the DNA containing G-quadruplexes had fewer breaks and so were protected from radiation,” says Prof. Raghavan. The results were published in the journal iScience.

Resilience of guanine

To test the resistance of guanine to radiation, the researchers started with single DNA strands. When single DNA strands made entirely of one of the four nucleotides — adenine, cytosine, guanine, or thymine — were exposed to gamma radiation, all except the strand made of guanine were sensitive to radiation.

In the case of a single DNA strand containing only thymine in one half and guanine in the other half, the guanine half alone showed better resistance to radiation.

But guanine loses its resistance when paired into double-strands and exposed to

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radiation. “We found guanine was resistant to radiation when present in a single strand but becoming sensitive to radiation when present in a double-strand form,” he says.

When the team made three double-stranded DNAs containing AT-rich, GC-rich and scrambled sequence and exposed to gamma radiation, all the three were equally susceptible to radiation. “When DNA is in normal double-helical form then guanine is equally susceptible to radiation unlike when it is in the G-quadruplex structure,” says Prof. Raghavan.

While dimethyl sulphate is able to cause DNA breaks when guanine is present in a double-strand, its ability to break DNA strands is compromised when guanine is present as G-quadruplex. “The position required for methylation [addition of methyl groups to the DNA] is occupied due to bonding, and so the G-quadruplex is resistant to dimethyl sulphate and no breaks are seen,” he says.

“Potassium chloride is essential for G-quadruplex formation. And in the presence of potassium chloride, the ability of dimethyl sulphate to induce cleavage in guanine is less, suggesting that guanine forms a G-quadruplex structure,” says NituKumari from IISc and one of the first authors of the paper.

Inside the cells

The researchers tested the radiation resistance of G-quadruplex inside cells. The cells were exposed to 10 Gray gamma radiation and then stained with a fluorescent-labelled antibody to study if the telomere remains protected.

“There were fewer DNA breaks in the G-quadruplex present in telomeres compared with centromere [another part of the chromosome]. This suggests that G-quadruplex offers radioprotection inside the cell,” says SumedhaDahal from IISc and another first author of the paper.

To reconfirm the protection offered by G-quadruplex, the researchers used an antibody that binds to the G-quadruplex structure and then irradiated the cell using 5, 10 and 20 Gray. “We examined the entire genome and found wherever G-quadruplex was present there was less DNA damage. Even at 20 gray gamma

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radiation no breaks were seen in the G-quadruplex structure unlike the rest of the genome," says SusmitaKumari from IISc and another first author of the paper.

Public database

Data available in public database of whole genome sequencing of two cell lines post-irradiation were analysed for radioprotection offered by G-quadruplex by collaborators from Institute of Bioinformatics and Applied Biotechnology (IBAB). "There were fewer DNA breaks in the regions where G-quadruplex is present unlike the other regions of the genome," says BibhaChoudhary.

To confirm the analysis of publicly available data, the researchers irradiated the genome and amplified the DNA sequences using a PCR. "All the genes that contained G-quadruplex structure showed less DNA breaks unlike other genes," says NituKumari.

Several other studies carried out too confirmed that G-quadruplex structure offered better protection to the DNA against radiation.

"Our study provides a new dimension to the role of altered DNA structures within the human genome, and helps study potential evolution of these structures. We also anticipate that our study will aid in exploring differential radiosensitivity across living organisms in correlation with the GC content of the genome," says Prof. Raghavan.

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CCMB team uses E. coli to study bacterial cell wall development

Researchers from Hyderabad have identified an enzyme that plays a crucial role in the enlargement and growth of bacteria, by studying E. coli. The enzyme MepK helps in cutting a particular class of bonds that connect the peptidoglycan, which is a sac-like molecule that envelops the cell. This action allows more material to be added to the cell wall, making a larger compartment for the cell to reside in.

One of the most important features of a bacterium is its cell wall which protects it from external environmental conditions and also internal pressure and keeps it

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in shape. Harming the cell wall causes irreversible damage to the bacterium and eventually kills it.

Crucial factor

For example, E. coli are rod shaped bacteria often experimented with in the lab. The bacteria die when the integrity of the cell wall is destroyed. Its crucial role in maintaining the wellbeing of the bacterium makes the cell wall a target of study, especially by scientists interested in developing new drug strategies to combat the bacteria.

In this context, understanding how the bacterial cell wall develops during growth and division of cells is an important question being addressed in Manjula Reddy's lab at the Centre for Cellular and Molecular Biology (CSIR-CCMB) in Hyderabad for a decade now.

In an earlier work, done in 2012, Dr Reddy's group showed that opening the cell wall by hydrolysing enzymes is crucial for the new material to be incorporated into it, leading to the cell's expansion and elongation.

The cell wall is made up mostly of a single net-like molecule (peptidoglycan). This consists of many sugar polymers interconnected by short peptides. It encloses the bacterial cytoplasmic membrane very much like a jute bag. The peptides connecting the baglike structure are cross-linked in several ways. Of significance to this work are the links between particular amino acid residues located on adjacent peptide chains. This is a rare component present only in bacterial cell walls and is known as mDAP for short..

Vital enzyme

In a paper published recently in the Proceedings of National Academy of Sciences (PNAS), the group identified an enzyme (MepK) which helps in breaking down the bond between two mDAP residues. This leads to cutting the molecular mesh and thus aiding the growth (or enlargement) of the cell. "By cleaving these cross-links, MepK [along with other known enzymes] contributes to growth and enlargement

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of sac-like peptidoglycan... This emphasises the fundamental role of cross-link cleavage in bacterial cell wall synthesis," says Pavan Kumar Chodisetti, from CSIR-CCMB and the first author of the paper.

"The class of enzymes reported in this paper was not known earlier, and identifying this enzyme [MepK] gave us lot of excitement," says Dr. Reddy. "[The study] has higher significance in organisms like Clostridia and M. tuberculosis because cell walls of these bacteria have very high levels of mDAP-mDAP type of cross-links. Therefore, MepK-like enzymes will be very important for the growth of these bacteria."

These cross-links constitute approximately 10% of total cross-links in Gram-negative bacteria like E. coli and Pseudomonas. However, they are predominant in many Gram-positive bacteria such as Mycobacteria and Clostridia (occur up to 80% of total cross-links)

The next step according to Dr. Reddy is "identifying small-molecule inhibitors for this class of enzymes and also to understand the molecular mechanisms by which the cell wall growth is initiated".

BIO-TECHNOLOGY

Novel molecule to combat multidrug-resistant bacteria

Screening a small-molecule library of about 11,000 compounds, researchers at the Indian Institute of Technology (IIT) Roorkee identified a potent molecule that exhibits broadspectrum bactericidal activity against multidrug-resistant bacteria — Escherichia coli, Acinetobacterbaumannii, Klebsiellapneumoniae and Mycobacterium tuberculosis. The molecule also shows antibacterial activity against Staphylococcus aureus and diarrhoea causing Clostridium difficile.

In mice infected with sepsis-causing bacteria A. baumannii, the molecule was found to significantly reduce the bacterial load in the spleen, lungs, kidney and liver at half the dose of a well-known drug nitrofurantoin. The results were published in Journal of Antimicrobial Chemotherapy.

Nitrofuran class

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The molecule belongs to the nitrofuran class of antibiotics — nitrofurantoin and furazolidone — which are routinely used for treating urinary tract infections and intestinal ailments, respectively.

The team led by RanjanaPathania from the Department of Biotechnology at IIT Roorkee found that the molecule kills the bacteria by damaging their DNA as well as by inhibiting cell division. When half the concentration required to kill the bacteria was used, the researchers found the daughter cells were unable to separate on cell division, leading to the bacteria forming into long filaments. “Since the molecule targets two pathways to kill the bacteria, microbes are less prone to resistance generation or would take a longer time to develop resistance,” says Prof. Pathania. “Even at 16-fold less concentration, the molecule was more effective in killing E. coli compared with nitrofurantoin,” she says. The molecule was found to be effective against both gram-negative and Gram-positive bacteria as well as against anaerobic bacteria such as C. dificile. Compared with nitrofurantoin and furazolidone drugs, the molecule was able to kill anaerobic bacteria at many times lower concentration. The team generated mutants to the molecule and ascertained that the molecule was a pro-drug like the rest of the nitrofuran class of antibiotics. Bacteria are less likely to develop resistance against a pro-drug as it becomes active only after getting inside the bacteria. The active components formed from the pro-drug are potent and short-lived, thus not giving the bacteria sufficient time to develop resistance.

Persister bacteria

Besides killing actively dividing bacteria, the molecule was effective against persister bacteria that remain in a dormant state. Persister bacteria can survive high doses of antibiotic treatment and are responsible for causing recurring bacterial infections. The researchers generated E. coli persisters and tested the ability of the molecule to kill them using two, four and eight times the minimum dosage required to kill the bacteria. “By the end of 12 hours, there’s a significant reduction in the persisters at four and eight times the MIC,” says TimsyBhando from IIT Roorkee and the first

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author. “Pro-drug does not differentiate between dormant and metabolically active bacteria and so they get into even the dormant bacteria. The molecule then kills the dormant bacteria by damaging the DNA.”

Doubly effective

Not only was the molecule able to inhibit biofilm formation (which helps bacteria to protect themselves from the action of antibiotics), but was also effective in disrupting the already formed biofilms. Compared with the molecule, both nitrofurantoin and furazolidone drugs displayed “poor ability” to eradicate already formed biofilms.

Bacteria generally can tolerate antibiotics by flushing out the drugs using the efflux pumps. “Even when we shut down the efflux pumps using an inhibitor, the amount of molecule required to kill the bacteria did not reduce much. So the efflux pumps are ineffective in pushing out the molecule from the inside the bacteria,” says Dr. Bhando.

Generally, reactive oxygen species (ROS) generated by a drug helps kill the bacteria. But in the case of the molecule identified by the team, generation of the reactive oxygen species followed bacterial killing. To ascertain if ROS generation killed the bacteria or was produced after the death of the bacteria, the researchers pre-treated E. coli with vitamin C, an antioxidant that removes the ROS. “Even after pre-treatment with vitamin C, bacteria were dying. So ROS is a consequence of DNA damage and was not the cause of bacteria death,” Pathania says. The study was done in collaboration with Government Medical College and Hospital, Chandigarh, AIIMS, Bhopal and AIIMS, Delhi.

BIO-TECHNOLOGY

New molecule for rheumatoid arthritis may be effective in preventing cartilage destruction

A specific fragment of a protein secreted by the parasitic worm liver fluke (Fasciola) has been found to protect the articular cartilage of joints from being destroyed by the body’s aberrant immune system, thus preventing rheumatoid arthritis from progressing. Besides protecting the cartilage from further destruction, the team of

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researchers from the Central Drug Research Institute (CSIR-CDRI) also found that the protein prevented the joint bone from being destroyed. In rheumatoid arthritis, the joint bone starts getting destroyed following cartilage destruction.

Liver fluke secretion

Liver flukes secrete certain specialised proteins that help the parasites to evade recognition by the host immune system and also blunt the killing machinery of the immune system by dialling down the inflammatory responses.

The protein — Fasciolahelminthdefence molecule-1 (FhHDM-1) — secreted by liver fluke has similarity with a human protein that mitigates inflammatory responses. So the team led by NaibedyaChattopadhyay isolated a specific fragment of this protein having a high anti-inflammatory function. They then synthesised and tested it in a cell culture system followed by animal testing.

The results were published in FASEB Journal.

A mouse model that is vulnerable to rheumatoid arthritis was used for testing the protective effect of the protein. The type-II collagen protein the major component present in the cartilage matrix of the joints but not as a whole protein seen in blood was introduced in large quantities to trigger an autoimmune response. With this, the process of cartilage destruction was set in motion.

Twenty days after introducing the antigen protein to trigger an autoimmune response, the researchers introduced the synthesised peptide every second day to evaluate its potential to protect the collagen from destruction. “The peptide rapidly stopped further damage to the cartilage. The cartilage that has already been damaged was not repaired because the damage is irreversible in the case of rheumatoid arthritis,” says Yasir Akhtar Khan from the Department of Zoology at the Aligarh Muslim University, Aligarh, and the first author of the paper. “Besides preventing cartilage destruction, the peptide also prevented the joint bone from destruction.”

Action on mice

The cartilage of animals that only received the type II collagen but not the peptide was completely destroyed by the end of the experiment (46 days), while the cartilage

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of the treatment group that received the peptide for four weeks was protected from further damage.

The effect of treatment in controlling cartilage destruction was assessed externally during the course of treatment by measuring paw swelling every day. “By 25 days of treatment, there was complete abolition of paw swelling compared with the diseased animals that did not receive any treatment,” says Dr. Khan. All the animals were sacrificed at the end of 46 days and the joints examined.

“There was extensive structural damage to the cartilage in mice that did not receive the peptide. The barrier that insulates the cartilage was destroyed leading to disease progression,” he says. “In the treatment group, the barrier was intact and comparable to the control group that did not have rheumatoid arthritis. We also did not see any immune cells in the joints of the treated animals.”

In contrast to the currently used anti-rheumatic drug (methotrexate), the biggest advantage of using the liver fluke peptide is that it does not produce a wholesale suppression of the immune system. Even the monoclonal antibodies that act against individual inflammatory molecules have inherent problems. For instance, the monoclonal antibodies target and suppress the tumour necrosis factor (TNF alpha), which is the first line of defence against Mycobacterium. In the Indian context, the anti-rheumatic drug and even the monoclonal antibodies that target TNF alpha will leave the person susceptible to infections, including TB.

Immune system intact

“The liver fluke peptide only produces selective protection to the joints and does not alter the systemic immune system. So the body’s ability to combat bacterial pathogens will remain intact. Dr. Chattopadhyay says. “We are yet to study the mechanism of selective joint protection (cartilage and bone) provided by the peptide.”

Thus, in the Indian scenario, the peptide that specifically prevents joint inflammation and destruction without affecting the body’s overall immune function might prove a game-changer in treating rheumatoid arthritis if further tests and trials find it

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effective.

Plants emit ultrasonic 'distress screams' when stressed

Researchers have for the first time found evidence of plants making airborne emission of ultrasound screams when subjected to stresses. The sound contains information that can reveal the state of the plant emitting it. The researchers experimented with tomato and tobacco plants and subjected them to two different stresses — drought and cutting of stems.

The ultrasound emitted is in the range 20-100 kHz and can be detected from a distance of 3-5 metres. The team led by LilachHadany from the School of Plant Sciences and Food Security at Tel-Aviv University which carried out the research speculates that if stressed plants can emit ultrasound, then neighbouring plants should be equipped to hear these distress sounds too.

"We don't know the mechanism of response in the plants yet. We have recently shown that plants' response to pollinator sounds involves their flowers, but we expect that receptors to ultrasound, if such exist, would be in the vegetative parts," Prof. Hadany says in an email to The Hindu.

Many moths, which use tomato and tobacco plants as hosts for their larvae, are already known to hear and react to ultrasound at frequencies emitted by the plants. "These moths may then potentially avoid laying their eggs on a plant that had emitted stress sounds," the write.

The results have been posted on bioRxiv preprint server; the manuscript is yet to be peer-reviewed.

Producing sound

The researchers suspect that the sounds are generated by a process called cavitation — where air bubbles form, expand and explode in the xylem causing vibrations. "Cavitation explosions have been shown to produce vibrations similar to the ones we recorded," they write.

The sounds were first recorded in the laboratory conditions using boxes that are

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acoustically isolated and then verified in greenhouses that were not acoustically isolated. They found that on average, tomato plants subjected to drought stress emitted 35 sounds an hour compared with tobacco that made just 11. However, when the stems were cut, the average number of sounds emitted by tomato plants dropped to 25 per hour while it increased slightly to 15 per hour in the case of tobacco. Controls emitted fewer than one sound per hour.

Greenhouse studies

In greenhouse, the researchers studied how the plants emitted sounds in response to lack of water. Watered tomato plants were placed in the greenhouse for 10 days without watering.

Very few sounds were emitted in the first three days when there was sufficient water. But the number of sounds per day increased on the fourth to sixth day and decreased as the plants dried.

Tomato and tobacco plants emitted ultrasound at different mean peak frequencies when subjected to the two stresses. In general, the two plants emitted sounds at a higher peak frequency when the stem was cut than when under drought. Under water-stressed conditions, the mean peak frequency was nearly 50 kHz for tomato and about 55 kHz for tobacco. When the stems are cut, the mean peak frequency was 57 kHz for tomato and nearly 58 kHz for tobacco plants.

Plants belonging to two different taxa also emitted ultrasound when subjected to the same stresses. “But the stresses were not identical, and we did not run a fully controlled experiment of them. We are sure that they emit sounds, and the peak frequency of the recorded sounds was in the same range, but all the rest would require additional experiments,” she says.

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Tackling drug-resistant A. baumannii

A novel molecule developed by chemically linking (conjugate) an amino acid (glycine) to a polymer has been found to possess high antibacterial activity against multidrug-resistant Acinetobacterbaumannii while showing no toxicity whatsoever

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to human cells. The antibacterial activity was also seen against clinical isolates of A. baumannii that are multidrug-resistant.

The team led by JayantaHaldar from the Antimicrobial Research Laboratory at the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru, found that the molecule has several other salient properties. The most important being its ability to kill even the dormant bacteria.

At 16 microgram per ml concentration, the molecule took about two hours to completely kill the actively dividing bacteria that are sensitive to drugs and two-four hours to kill drug-resistant strains of A. baumannii . However, at the same concentration, the molecule needed less than two minutes to kill the dormant, drug-sensitive bacteria, and about five minutes to kill the dormant, drug-resistant bacteria. “At this point in time we don’t know the reason behind the rapid killing of the dormant bacteria,” says Prof. Haldar.

Disrupting biofilm

Since A. baumannii bacteria display great propensity to form biofilm, the researchers tested the ability of the molecule to disrupt biofilm. They found that the molecule could disrupt the biofilm formed by both drug-sensitive and drug-resistant A. baumannii. “At 64 microgram per ml concentration, the efficacy of the molecule to disrupt the biofilm was comparable with the last-resort antibiotic colistin,” says Prof. Haldar.

“One dose of the molecule was able to achieve 65% biofilm disruption when the concentration used was 64 microgram per ml. If we use the molecule repeatedly then it can completely disrupt the biofilm,” says Swagatam Barman from JNCASR, the first author of a paper published in the journal ACS Applied Materials & Interfaces.

The toxicity of the molecule was tested using human embryonic kidney cell line. Not a single cell was killed when 8-16 microgram per ml concentration was used. Even when the concentration was increased to 500 microgram per ml, about 80% cells were still not killed. “The molecule did not show any toxicity at the concentration needed to kill both drug-sensitive and drug-resistant bacteria,” Barman says.

The researchers also tested if the molecule killed red blood cells. Even at 1,000

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microgram per ml concentration, which is several times the concentration needed to kill the bacteria, only about 1-3% of red blood cells were destroyed.

Killing mechanism

A. baumannii bacteria are already resistant to most antibiotics. So to evaluate how quickly the bacteria would develop resistance against the synthesised molecule, the researchers exposed the bacteria to the molecule for 14 days. “The bacteria did not develop any resistance against the molecule at the end of 14 days, while the bacteria exhibited 250-fold resistance against meropenem drug,” says Prof. Haldar. “The bacteria developed a high level of resistance against the last resort antibiotic colistin too.”

The molecule is able to destroy the integrity of the membranes thus killing even the multidrug-resistant A. baumannii, Prof. Haldar says. Gram-negative bacteria have an outer and an inner membrane thus making it difficult for drugs to effectively kill them unlike in the case of Gram-positive bacteria that have only one membrane.

The molecule was found to destroy the integrity of the outer and inner membrane and permeate through the membranes even at a low concentration of 5 microgram per ml. The permeability increased when higher concentration of 20 microgram per ml was used.

“We will soon be studying the efficacy of the molecule in animal models,” Prof. Haldar says. “Based on the in vitro studies, we feel this molecule has immense potential for being developed as a future therapeutic agent.”

BIO-TECHNOLOGY

Mutation in smell gene found to be associated with asthma

Based on a study of a four-generation family in Mysuru with high prevalence of asthma, a multi-institutional study by Indian researchers has shown that a variant of an olfactory gene (OR2AG2) is a novel candidate for asthma. This is the first time in India a four-generation large family with high asthma prevalence has been studied for the said purpose.

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The gene was validated in a north Indian cohort of 141 children with asthma and 130 controls. About 80% of children with asthma carried a copy of the gene variant.

Twenty individuals representing the four generations were selected. Of the 20 persons studied, 14 had asthma and the rest served as a control group. Whole genome genotyping was undertaken on all the 20 participants and exome sequencing was carried out on five people with asthma and three controls. While whole genome genotyping helps in detecting variations across the genome, the exome sequencing allows variations in the protein-coding region of any gene to be identified.

Several variants were seen after genotyping and exome sequencing. The team led by Anurag Agrawal, Director of the Institute of Genomics and Integrative Biology (CSIR-IGIB), Delhi, turned to computer modelling to narrow down the possible variants that might be responsible for asthma and finally confirmed the genetic variant through conventional sequencing.

"Mutation in the sensory pathway such as olfaction is a plausible mechanism for increased asthma risk because of inability to mount an appropriate counter response. The inability to mount a counter response could lead to lung damage," says Dr. Agrawal. The inability to smell could be a potential mechanism for lung damage.

Identifying odour

To test this, the researchers evaluated the ability of the 20 participants to smell a sweet odour and the concentration at which they could identify the odour. All 14 family members with asthma had one copy of the gene variant.

"Healthy individuals and those with asthma were able to identify and differentiate different smells, but those with asthma could detect smells only at higher concentrations," he says. "This suggested a defect in their ability to smell. Also, family members with asthma said they could not smell burning odour."

"Whether olfactory gene was associated with asthma or not was not known till now. Ours is the first study to find such an association," says Dr. SamarpanaChakraborty from CSIR-IGIB and the first author of a paper published in the journal Scientific

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Reports. “The gene variant may cause olfactory dysfunction in the family members who have asthma.”

“By studying the four-generation family alone or the children cohort individually, we couldn’t have identified the gene. We needed both groups,” Dr. Chakraborty says. “In population-based studies that have been undertaken, it becomes difficult to identify such variants.”

“There are three main reasons why we could identify the gene variant — asthmatics in the family had difficulty in smelling, we saw the same variant in the cohort and we were looking for a novel genetic variant,” Dr. Agrawal says.

Suppressing expression

But during the validation studies, asthmatic children with or without the variant did not show significant difference in the ability to smell, which was unexpected. “Asthmatic children without the variant too had impaired smell threshold, which made us wonder if asthma-related pathway itself can cause suppression of the gene independent of the genetic variation,” he says.

To validate the hypothesis, the researchers directly measured the gene expression in lung samples of those with asthma and normal subjects. In people with asthma, there was significant reduction in the expression of the gene.

They also carried out cell culture studies. When the cultured human cells were treated with IL13 cytokine, which is associated with allergy, there was suppression of OR2AG2 gene expression.

“So there is either a genetic defect in the OR2AG2 gene at birth leading to suppressed expression or there is acquired suppression of gene expression later in life due to inflammation or environmental factors,” he says. “This supports our hypothesis that the gene may be a convergence point for asthma pathways at the lung level.”

BIO-TECHNOLOGY

IIT Hyderabad team uses plant extract, heat to kill cancer cells

Lipid-based nanoparticles encapsulating chlorophyll-rich extract of a medicinal

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plant Anthocephaluscadamba and a near-infrared dye has been found to selectively kill cancer cells when exposed to near-infrared light.

Unlike the conventional photothermal therapy that relies on heat to kill cancerous cells, a multi-institutional team led by researchers from the Indian Institute of Technology (IIT) Hyderabad used heat generated by the dye when exposed to light to destroy the encapsulation and release the extract.

Through in vitro studies, the team led by Aravind Kumar Rengan from the Department of Biomedical Engineering at IIT Hyderabad found that the extract generated excess amount of reactive oxygen species, which caused cell death through autophagy (body's way of removing damaged cells).

Collaborative effort

Researchers from the University of Hyderabad, IIT Bombay and Bose Institute, Kolkata, were part of the study and the results were published in the journal Nanoscale.

The extract showed selectivity in killing only cancer cells; the extract released inside normal cells caused insignificant cell death. The reason: the extract did not increase the amount of reactive oxygen species generated inside normal cells thus not causing them through autophagy.

"In our study, heat is used mainly to destabilise the lipid nanoparticle encapsulation and release the extract," says Prof. Rengan. "We optimised the amount of dye used and the duration of illumination so that the thermal effect is mainly for triggering the release of the extract."

Potent mechanism

The lethal effect of the extract to kill the cancer cells when exposed to thermal energy was already demonstrated by the team a couple of year ago. But the mechanism through which the extract killed the cancer cells was not known then. "Based on studies using breast cancer cell lines we found that the extract increased the generation of reactive oxygen species, which enhanced autophagy-mediated death of cancer cells," he says.

When photothermal therapy alone was used, nearly 50% cancer cells died in about 24

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hours. But 45% cancer cells grew back in about a day. “But there was no significant growth (about 7.5%) of cancer cells even 48 hours when photothermal therapy was used along with the extract. The extract was able to restrict cancer cell growth,” says TejaswiniAppidi from IIT Hyderabad and one of the first authors of the paper.

Autophagy-mediated cell death was confirmed by using a particular protein that serves as an autophagy marker. “When cancer cells were treated with the extract, the amount of protein marker generated showed an increase. The protein marker produced varied depending on the amount of extract used,” says Deepak BharadwajPemmaraju from IIT Hyderabad and the other first author of the paper.

Reactive oxygen

Since the extract increased the amount of both reactive oxygen species and autophagy, the researchers set out to explore the link between the two. They used a known chemical that inhibits the generation of reactive oxygen species and then treated the cancer cells with the extract. “Cells where the ROS generation is inhibited showed negligible cell death due to reduced autophagy” says Appidi. “This helped confirm the role of reactive oxygen species in causing cell death.”

Similarly, the researchers used an inhibitor to prevent autophagy and treated the cells with the extract. “We saw significant reduction in cell death in the presence of the extract when autophagy was inhibited. This helped confirm the role of autophagy in causing death of cancer cells,” says Pemmaraju. “These two experiments helped confirm that the cell deaths that occurred could be due to ROS-mediated autophagy.”

The efficacy of the nanoparticles containing the plant extract and dye was tested in mouse model with breast cancer. The tumour volume reduced significantly when treated with the extract along with photothermal therapy compared with controls and cells treated with the extract alone. “But the nanoparticles had no adverse effect on the body weight of mice, indicating the biocompatibility of the nanoparticles,” says Pemmaraju.

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BIO-TECHNOLOGY

Carbon dots help detect herbicide pollution

In an extraordinary waste-to-wealth feat, researchers from Assam have used the commonly found invasive plant water hyacinth to produce carbon nanoparticles. These extremely tiny (less than 10 nanometre) particles can be used for detecting a commonly used herbicide — pretilachlor. The nanoparticles were found to be selective and sensitive for the detection of the herbicide.

“At the biodiversity hub of our institute we have been trying to figure out how to convert this weed into a value-added product. Here in Assam, every water body is infested with water hyacinth, and it was an easy and cheap option to explore. Some teams are exploring if its fibre can be used to make furniture. We are also working on making activated carbon using the plant and these carbon dots were one of the innovations born in our lab,” explains Devasish Chowdhury from the Material Nanochemistry lab at the Institute of Advanced Study in Science and Technology, Assam. He is the corresponding author of the work published in Heliyon.

Leaves to carbon

The team harvested water hyacinth leaves, removed the chlorophyll, dried and powdered it. The sieved powder underwent several treatments including heating at 150 degree Celsius to convert it to carbon dots. “When a nanoparticle is less than 10 nanometre we call it a dot or nanodot. Our carbon dots were able to give a green fluorescence under UV light. The extremely small oxygen functional groups on the surface of the dot are responsible for the fluorescence,” explains the first author of the paper ManashJyotiDeka.

The herbicide pretilachlor is mixed with water and carbon dots, and studied using special equipment. The fluorescence intensity increases in the presence of the herbicide. The team also tested using different pesticides and other compounds having similar chemical structure and found that the carbon dot was extremely sensitive to pretilachlor and could detect even very small quantity of the herbicide. After successful testing in the laboratory conditions, the team collected soil samples

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from different places across the State and proved the efficiency of the carbon dots in detecting pretilachor in soil samples.

Fluorescence enhancement

The paper also describes the mechanism by which electron transfer happens between the dot and the herbicide which enables the fluorescence enhancement. Dr. Chowdhury adds that this will be a commercially viable option when compared with the sensors currently available in the market, as the raw material for the construction of the sensor — the water hyacinth — is readily available and is practically a waste material. Based on this study, the group is now developing a paper strip–based sensor for on-site detection of pretilachlor.

Computer & IT

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COMPUTER & IT

Draining cell phones

Q. How does a fully charged mobile phone lose its charge when left unused for several days together?

Lithium-ion battery chemistries are associated with self-discharge phenomena. A passivation layer develops on the electrodes over time (on performing several charging-discharging cycles) which results in self-discharging of the battery. It means internal chemical reactions reduce the stored charge of the battery without any connection between the electrodes or any external circuit. Studies show a self-discharge rate of Li-ion battery is 5% in 24 hours, then 1–2% per month. It must be borne in mind that even when the phone is kept idle, there are a lot of applications working in the background like phone-watch, calender, to name a few. These applications in-turn cause a charge loss.

Q. How does water rise up tall trees during autumn and winter when there is very less water evaporation from leaves?

During late autumn and winter deciduous trees are dormant. The colder temperatures during these seasons are not optimal for most physiological reactions in cells. Therefore, trees do not need a lot of water in the winter. The amount of transpiration is only one-sixth that during the peak growing season. Trees can also store water in their stems which they use during the winter. This also reduces the need for transpiration to obtain water during the winter.

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HAL sticks with ELM-2052 AESA Radar for Tejas Mk1A, hints at advance and better derivate

With latest media reports hinting that indigenously developed UTAAM AESA Airborne AESA Fire Control Radar (FCR) will be ready for integration and trials with new upcoming updated Tejas Mk1A within next one year, HAL Sources close to idrw.org have confirmed that the management is still sticking with the Israeli ELM-2052 AESA Fire Control Radar for Tejas Mk1A program and swapping Israeli AESA FCR with Indian AESA FCR is not been considered for time being for various reasons.

HAL source close to idrw.org confirms that LRDE and DRDO have kept IAF and HAL in the loop about progress made by the UTAAM Team on the LCA LSP-2 which has been Test-bed aircraft but the Test-bed (LSP-2) is now down for regular maintenance and weapons modes are yet to be activated and its software integration is yet to be performed which means Radar will take time to mature.

When asked about UTAAM AESA FCR performing better than the ELM-2052 AESA FCR in developmental trials, idrw.org was informed that EL/M-2052 Active Electronically Scanning Array (AESA) equipped onboard the Jaguar DARIN III fighter jets of the air force have smaller antenna size and Power supply due to under-powered engine and smaller nose cone size found on the Jaguar fighter jets which came initially with very basic small radar system in the ’70s.

idrw.org was given hints that Tejas Mk1A will be getting advance derivative of the EL/M-2052 AESA FCR which has possible bigger antenna size and with additional Power supply option then what was procured by the HAL previously for the Jaguar DARIN III fighter jets. ELTA Website maintains that EL/M-2052 can weight from 80kg to 180kg depending on the size of the antenna used on the aircraft and requires a power supply from 3-10 kVA again directly related to antenna size which explains the claim made to idrw.org also confirming that their exits Modular hardware and software growth potential of the Radar on the offer.

HAL’s Mission & Combat System Research & Design Centre will be in charge to work closely with ELTA engineers for integration and testing of the EL/M-2052 AESA FCR

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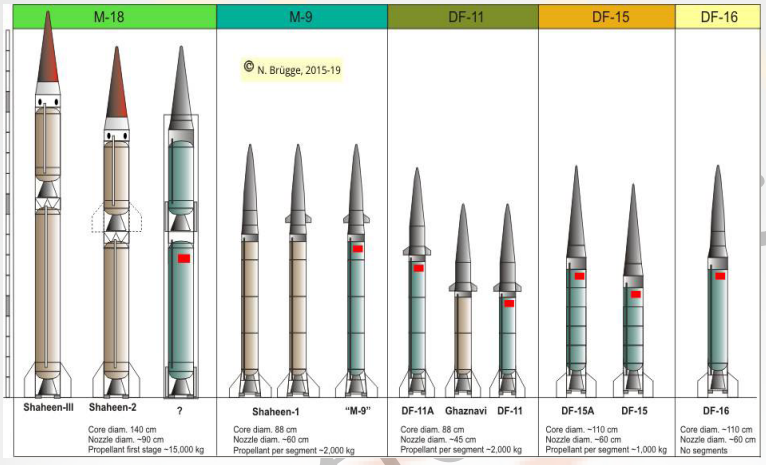
when it is supplied for integration in 2021-22. ELTA engineers have a past history of working closely with the HAL engineers in Bangalore for MMR/2032 Hybrid Radar used on the Tejas Mk1 and ELM-2052 on Jaguar DARIN III fighter jets, they have assured full cooperation also on Tejas Mk1A program.

Pakistani Missile Scientist leaks Shaheen-II and III details



Pakistani Deep state has hanged Two individuals for spying for the American CIA. According to media reports, Pakistan Army's Brigadier Raja Rizwan (retd) along with lead missile Scientist named WasimAkram of the land-based Shaheen-II and Shaheen-III surface-to-surface medium-range ballistic missile who worked for Islamabad-based National Engineering and Scientific Commission (NESCOM) which itself has been based on China supplied M-18 [DF-15].

According to media reports, WasimAkram who was a metallurgical engineer played a crucial role in the local production of the Chinese M-18 ballistic missile in the county and was also vital in matting of the Pakistani nuclear weapons in the weapon system. He was recruited by Central Intelligence Agency to provide crucial details of both the missile system including details of its classified payload and range.

CIA was largely interested in knowing range vs payload calculation of the missile and what trajectory it will fly which has been leaked by the Wasim to the CIA. Shaheen-II (1500-2000km) and Shaheen-III (2750km) both are the longest missiles which

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provides Pakistan full coverage of India including its southern part of the country which was out of range before their development.

While the Pakistani Deep state has maintained its silence on the matter, the information which the CIA has collected about the missile system will come handy in the interception of the missile system which comes as a bloody blow to the Pakistani military which are counting on this two missile to carry nuclear warheads in case of full-fledged war with India. CIA due to Wasim, now has details of the missile range vs what payloads it can carry and what trajectory it will follow when loaded with a conventional and nuclear payload.

Both India and the United States of America have been closing monitoring Pakistan's missile development for years now and both countries have developed Missile Interceptors to engage and destroy such missiles in the sky when it is launched. Details of both Shaheen-II and Shaheen-III missile system will likely be shared with India so that the Indian missile interceptor battery which has completed its developmental trials will have better mid-air interception capabilities.

DEFENCE

DRDO shows upcoming 122 mm Medium Range Precision Kill System (MRPKS) Rocket

In April this year (Indian Army wants "Desi BM-21-Grad " Multiple Rocket Launcher for Mountain terrain), idrw.org was first to break cover on the development of a

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Medium Range Precision Kill System (MRPKS) to be equipped for its light regiments to replace its aging Soviet truck-mounted 122 mm BM-21 “Grad multiple rocket launcher systems from its inventory on request of the Directorate General of Air Defence Artillery of Indian Army.

DRDO has showcased a full-scale model of the upcoming 120mm Rocket along with the Pinaka MBRL family. MRPKS has been developed specifically for mountainous terrain where lighter 4×4 Trucks are easier to move then Heavy 8×8 and 10×10 Vehicles. According to details revealed, MRPKS will be mounted on current in-service Trucks and can carry a minimum of 24 rockets each and has a range of at least 25km and accuracy of two meters at the target end. The Army has asked for a vertical launcher that has 360-degree deployment capability so that it has no crest clearance issues in hills.

Army has sanctioned 30 crores as the estimated development cost for one set of Ground Support Equipment and ammunition for validation of the Prototype equipment. MRPKS will be below Pinka Mk-1 which has a range of 40km.

NAL reveals details of the RTA 90-NG

India is working on developing its 90-seater aircraft with National Aerospace Laboratories (NAL) being lead in charge of the program, details of the upcoming new Gen Regional Transport Aircraft (RTA 90-NG) were recently shared by the NAL and its road map to develop them. RTA 90-NG will have both turboprop and turbofan

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variant and NAL has proposed to construct a total of seven developmental models in a different configuration and different vendor engines to attract different civilian operators in India.

idrw.org has been informed that NAL also planned a Large Cargo Door Freighter variant to be used for Cargo service operators and even a military variant has been planned for troop transportation duties. NAL is reportedly in discussions with global engine manufacturers such as Pratt & Whitney of Canada and General Electric of US and avionics firms like Rockwell Collins and Diehl Aerospace for the supply of off the shelf critical components for the program.

India Specific Requirements for RTA will mean that it will compete with Bombardier developed Q400 Turboprop which was first 90?passenger model which according to Franco-Italian company is all set to grow further since more manufacturers are now proposing to develop their 90-Seat Turboprops for possible order over 1,340 such aircraft over the coming 20 years.

Q400 Turboprop already has cornered 600 confirmed orders from various operators worldwide and 50 coming from SpiceJet Limited ("SpiceJet") based in India. According to NAL, the total requirement for RTA 90-NG will be around 250-300 units in the Indian market for both its Turboprop and Turbofan variant.

When asked by idrw.org of any proposal to develop a multi-mission aircraft (MMA) for maritime surveillance for Navy or Ramp variant for Cargo operations by the Air force based on the RTA 90-NG, we were told no such proposal exists but military variant based on armed forces requirement will be considered at a later stage but RTA 90-NG will be offered to Military for Troop Transport operations. NAL plans to have a first developmental model of the RTA 90-NG ready by 2025.

- Performance: Range with 90 Pax 1500 Km
- Balanced TO Field Length (ISA, SL, MTOW) 1200 m
- Landing Field Length (ISA, SL, MLW) 1100 m
- Ceiling 27000 ft

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- Cruise Speed 550 kmph
- Configuration: 90 seat (civil), Cargo , Military

Features

- Acquisition cost: 20-25 % lower
- Operating cost: 20-25% lower
- Fuel Consumption: 10-15 % lower
- Maintenance cost: 20-25% lower
- Take-Off & land from unequipped airfields
- All-weather operation
- Emissions lower by 70%
- Enhanced safety
- More cabin and cargo space

DEFENCE

After Successful Twin trials of Spike ATGM, Rafael takes a dig at DRDO's ATGM program

After India's apparent U-Turn on a tender for 321 ATGM launchers and 8,356 missiles worth an estimated $500 million from the Rafael Advanced Defense Systems for the Spike LR anti-tank guided missile (ATGM) in 2018, Rafael Advanced Defense Systems in an apparent dig at India's state-owned Defence Research and Development Organisation (DRDO) and its ongoing Man-Portable Antitank Guided Missile

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(MPATGM) program said that “With confidence in the Spike missile established, the Indian Army may need to revisit their plans on DRDO program”.

In 2018, a $500-million purchase of Spike LR missiles from Rafael was canceled by India to favor the indigenous MPATGM program developed by the DRDO but due to ongoing tension with Pakistan at the border, Indian Army was allowed to procure a limited quantity of Spike LR missiles, to meet the urgent operational requirement.

MPATGM for the first time was test-fired in full configuration in the ranges of Kurnool, Andhra Pradesh earlier this year but already on fast track mode, the ATGM will not be ready for production until 2022. Many Defence analysts are also worried about the Army’s never-ending saga of user trials which may lead to further slippage in the program if the Army insists on some improvements.

In the recent Army test, Israeli Spike LR anti-tank guided missile (ATGM) homed on to the target at a distance of 4km successfully but ATGM has been in controversy after it was revealed after its selection that at the evaluation stage missile was finding it hard to hit targets at its max range in desert heat conditions of Thar desert in peak summer months in India.

DRDO reportedly has demonstrated MPATGM at a max range of 2.5km and its 4km maximum range requested by the Indian Army is where things can get a little interesting and why Rafael Advanced Defense Systems took a dig at DRDO.

DRDO official in the past have claimed that the MPATGM is technologically equivalent to the American FGM-148 Javelin and Israeli Spike man-portable fire-and-forget anti-tank missile but might have a shorter range (2.5km) variant available first and later a longer range (4-4.5km) variant will be developed at a later stage, just how Israeli Spike ATGM family has Spike-MR (2.5km) and Spike-LR (4km) variant procured by Indian Army.

Indian Army has not clarified if it is ok with such an arrangement since the Indian Army already has in its possession over 25000 Russian developed second-gen 9M113 Konkurs-M ATGM with a similar range as offered by DRDO initially on the third-gen MPATGM. DRDO is yet to clarify if the MPATGM will come with a requested

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range of 4km or with 2.5km yet.

TEDBF will be in the same Class as Mig-29K and Rafale-M: ADA

Dr.GirishDeodhare program Director of ADA speaking to Business Standard for the first time has confirmed that Aeronautical Development Agency is indeed working on the development of a carrier-based Twin engine Mark-2 Program for the Indian Navy, while it prepares to demonstrate landing and take-off capabilities of single-engined Naval-LCA from the Aircraft Carrier INS Vikramaditya by March 2020.

ADA earlier this year at Aero India 2019 had showcased a Navy-LCA Mk2 with Max takeoff weight (MTOW) of around 16.5 tonnes powered by a single-engine supplied by US engine-maker General Electric (GE) F414IN engine generating 98 kN thrust class but it was rejected by the Indian Navy due to Thrust to weight ratio and Navy also wanted safety of the second engine for smooth carrier deck operations.

According to details revealed by Dr.GirishDeodhare, Twin Engine Deck Based Fighter (TEDBF) will be powered by Two F414IN engines generating 98 kN thrust class each and now will be bigger and heavier than the Navy-LCA Mk2 concept which was showcased at Aero India 2019 earlier this year.

TEDBF will have Max takeoff weight (MTOW) of around 24 tonnes which puts it in the same class as that of other carrier-based fighter jets like Rafale-M (24.5 tonnes) and Mig-29K (24.5 tonnes) which is already operated by the Indian Navy. TEDBF will also be in the same weight category has that of the 5th generation stealth AMCA

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program which is under development for the air force which also falls under 25 tonnes.

According to information provided to idrw.org, the current fleet of 43 Mig-29K will be relieved of its carrier-based duties once TEDBF is inducted from 2031 onwards and instead Mig-29K fleet will be used from shore-based Naval facilities for patrolling and combat missions instead of being retired as reported by other media outlets.

Dr.GirishDeodhare has confirmed that the first roll-out will happen by 2025 and the first flight of TEDBF will happen by 2026. Technologies developed for the Naval-LCA Mk1 program will be used for the TEDBF program, while other technologies will come from MWF-AF and AMCA programs which are also in development.

Two years back, the Indian Navy had issued RFI to supply 57 fighter jets to Navy and four players Rafale-M (Dassault, France), F-18 Super Hornet (Boeing, US), MIG-29K (Russia), Sea Gripen (Saab, Sweden) had responded to the RFI issued by the Indian Navy. It is more or less can be assumed that due to the development of the TEDBF program, the Indian Navy is likely to stick with the local 4.5 generation program while it invests in the 5th Generation Naval-AMCA program soon for operations from the second indigenous aircraft carrier.

DEFENCE

Saras Mk-II will be superior to Dornier Do 228 in performance: NAL

The government-run aerospace laboratory National Aerospace Laboratories (NAL) is looking to mass-produce Saras Mk-II, a 19-seater multi-role light transport

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aircraft, by 2025 for the civilian market and also offer it has an ideal replacement to the Dornier Do 228 twin-turboprop STOL utility aircraft manufactured by Hindustan Aeronautics Limited (HAL) in Kanpur in operations with Indian Air Force, Indian Navy, and Indian Coast guard.

NAL plans to develop two developmental models to be certified for military followed by civil under FAR23 and to be manufactured by HAL in Kanpur facility where currently Dornier Do 228 are been manufactured under license from Dornier GmbH from 1983 onwards for the Indian Armed forces.

According to NAL, Saras Mk-II will have better Max take-off weight, range and cruise speed when compared to the Dornier Do 228 and will also feature full Glass Cockpit with Autopilot & Hydraulic boosted Rudder and will be able to operate from ill-equipped & high Altitude Airfields.

	SARAS Mk II (India)	Do 228 NG (German)	Beechcraft 1900D (USA)	LET 410 NG (Czehs)	Lapan N219 (Indonesia)
Take-off Weight (kg)	7400	6400	7764	7000	7030
Max Cruise Speed (km/hr)	540	440	533	417	389
Range with Max Payload (km)	700	440	679	442	889
Cabin	Pressurized	Unpressurised	Pressurized	Unpressurised	Unpressurised
Specific Range (km/kg)	1.6	1.4	1.52	1.22	1.11

NAL sees a market for around 150-200 of the Saras Mk-II, While Indian Air Force has committed to 15 and are expected to demand 45 more.

DEFENCE

How TEDBF program unfolded by the Indian Navy and ADA

ORIGINAL ADA CONCEPT FOR 4.5 GEN MCA FIGHTER JET FOR AIR FORCE

Twin Engine Deck Based Fighter (TEDBF) program for the Indian Navy aims to provide a 24-tonne Twin-engine fighter aircraft which will replace the Mig-29K fleet in the Indian Navy. Navy has asked ADA for TEDBF to be better than the Russian Supplied Mig-29K fighter jets which currently operates on the deck of INS

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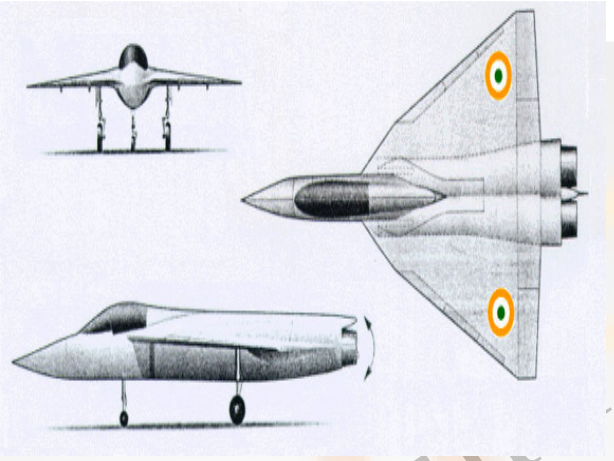
Vikramaditya. Indian Navy joined the LCA-Navy Mk1 program a little late in 2004-5 fully knowing that it won't be able to meet its operational requirements, initial funding was to develop technologies required to develop an Mk2 fighter jet which can operate from the deck of the aircraft carrier.



In 2016, Indian Navy was having second thoughts on the development of the single-engined medium role Naval Mk2 fighter jet and had informed ADA that it could rather invest in a Twin engined 5th generation stealth aircraft over a single-engined Naval Mk2 and soon it was decided that Naval Mk2 program will be abandoned and ADA will start clean slate 4.5 generation fighter jet program for the Indian Navy .

ADA did a feasibility study on the 5th Generation AMCA for the Navy but both agreed that technology maturity for carrier-based Naval 5th generation jet is still not there until and unless ADA has some experience in development of Naval jet capable of operations from the aircraft carrier, so LCA-Navy Mk1 prototypes (NP1 and NP2) which were sitting idle in the hangar in Bangalore for over a year was reactivated and the focus shifted to get the technology know-how crucial to a carrier-based aircraft first before next program can be announced which meant program has to clear many milestones required and it did achieve almost all set milestone required by the Navy before it could commence aircraft carrier trial which will start soon.

Naval Mk2 model displayed at the Aero India 2019 created a lot of confusion initially and many were not sure if the Navy doesn't want to operate a single-engine fighter

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jet from its aircraft carriers then why ADA was still working on the Mk2 design showcased at the Aero show. It is more or less confirmed now that the work on the TEDBF program started around the 2016-17 period itself even when ADA was carrying out feasibility studies on the Naval-AMCA only thing it was kept under wrap waiting for Navy's approvals.

Navy has two options let ADA work on the development of clean sheet 5th generation fighter jet which according to the promised timeline could make its first flight by 2030-31 and will enter around 7-8 years down the line, once major work on the air force's AMCA program is completed or agree to allow ADA work on Naval-AMCA version but ADA had identified some of the problems that the program it was gonna face and certain shortfalls in the operational capabilities which Navy had to live with due the conversion of airforce variant into naval variant due to which Navy agreed to pursue the development of 5th generation fighter at a later stage.

But Navy had to still decide between two 4.5 generation programs offered by the ADA. Single engined Naval Mk2 concept proposed by the ADA was a 16.5-tonne aircraft with many unique features with better carrier handling characters but Navy apparently wanted the comfort of the second engine for safety reasons and also was not impressed with the weapons load it could carry which was due to screwed thrust-to-weight ratio (TWR) which forced pilot to rely more on aerodynamic lift which is not preferred by Naval pilots when rough seas can make landing back on the deck of an aircraft carrier a herculean task,so after careful consideration it was rejected in somewhere around 2018.

TEDBF program was approved after careful consideration looking into the future requirements of carrier-based aircraft which can serve both on INS Vikrant and INS Vishal from 2031 onwards. Navy had planned to procure 57 Carrier-based fighter jets after not so impressive record of the Russian Mig-29K fleet in the service and also due to budget issues, it is unlikely it will be approved due to which Navy cleared TEDBF program over Naval Mk2 concept to be future-ready when it is ready for

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induction after 2030.

At 24 tonnes, TEDBF will have the same Max take-off weight has that of the Mig-29K and Navy already has briefed ADA about all the serious flaws and issues it has been facing with the aircraft and ADA now will develop an aircraft which is superior to the performance of the Mig-29K. Navy wants TEDBF to be Multi-Role and be able to handle Air Defence and Anti-ship and Ground attack roles with ease. Powered by two F414-GE-INS6 engines, at 24 tonnes with two 98 kN Thrust class engines it will have TWR ratio which will be better then that of the 1.09 which is of the Mig-29K if ADA can achieve its Empty target weight of 11 tonnes.

Mig-29K is powered by two RD-33MK engines generating 88.3 kN of the thrusts each due to which it was able to achieve a TWR ratio of 1.09. If ADA can hit that sweet empty weight spot of 11 tonnes in the TEDBF program then due to more powerful engines it will have a TWR ratio of 1.13 or even better which is the same that of the Rafale M and were close to the TWR ratio of 1.14 of the Su-30MKI.

Way a Head

TEDBF program is already in the design stage and according to media leaks that are coming out it will just not be a twin-engined Naval Mk2 concept which was showcased earlier rather it will be based on various twin-engine MCA designs which ADA design team had worked on before development began on the AMCA program.

ADA design team which worked on the LCA-Navy Mk1 prototypes and proposed Naval Mk2 concept is working on the TEDBF program again and problems faced by the team on the LCA-Navy Mk1 prototypes was largely due to over-engineering of the components which lead to several revisions in the design and hardware to reduce weight, especially its landing gear mechanism.

Funds

ADA Navy design team is now 10 year veteran in the design and development of the Naval fighter with only two prototype development and is confident that the initial prototypes can be developed as per money committed by the Indian Navy to the Mark-2 program for which funds already has been approved by the Government

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some time back.

Navy will have to commit more money at a later stage of the TEDBF program but now it gets to build a jet it wants as per its customization and not depend on the aircraft designed as per requirements set by a foreign navy. Navy has committed to procure 50 initially but that figure can go up if the 5th generation Naval fighter program is dealyed. ADA almost has the design ready of the TEDBF but has still kept it under the wraps and might be showcased soon in upcoming defense expo 2020 or at the Aero India 2021.

ADA has promised to divert money it has secured for the development of two LCA-Navy Mk2 to develop the first two TEDBF prototypes which will be ready by 2025 for rollout and by 2026 for its first flight. ADA and Navy will have a separate team for the TEDBF program and it will be based in the INS Hansa Goa so that initial trials from the shore-based aircraft carrier ramp and landing stip can be used to handle phase-I of the trials later to be shifted to the aircraft carrier trials. ADA believes that both Phase-I and Phase-II can be divided into three years each so that it is ready to hit production by 2031-32.

SPG to procure Desi JVPC for PM Modi's Security

Special Protection Group (SPG) which is in charge of providing security to the Prime Minister of India NarendraModi will now sport a new weapon in their long list of

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arsenals. SPG which carried out trials on the DRDO developed but OFB produced Joint Venture Protective Carbine (JVPC) has reportedly cleared all trials of the SPG and now will be inducted into the Elite Special force.

CRPF already has placed orders for 10000 JVPCs and the first lot was handed over to CRPF in 2017. JVPC also has been ordered by State police from Madhya Pradesh, Delhi, and Meghalaya as well while it waits orders from the Indian Army for which it was developed.

JVPC has a 5.56 mm calibre bullets with a magazine capacity of 30 cartridges. JVPC has a much shorter effective firing range and is capable of penetrating soft body armor made of kevlar.

India being breified regularly on Su-57 Program : Russia

Su-57E was displaced with engine cowlings

Rostec officials have confirmed that Indian officials have been getting a regular briefing on the progress of the fifth-generation Su-57 fighter jet program from them and are still hopeful that India will be among the first few countries who will procure Stealth Su-57E fighter jets from Russia in near foresee, as per information provided to idrw.org, Russia is keen to address issues pointed out by IAF with the aircraft as it gears up to mass manufacture the aircraft for the Russian air force.

Su-57 has conducted 16 flights with the second stage engine known as Item 30 which comes equipped with a fully electronic automatic control system and ensures

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the fighter's super-maneuverability, thrust-to-weight ratio, stealth characteristics and the ability to perform cruising flights at supersonic speed.

Recently Su-57E was displaced with engine cowlings on the top and lower completely covering the exposed unpainted metal section of the engine from previous prototypes, which according to Rostec officials have decreased some of these deficiencies of the rear side of stealth characters. Izdeliye 30 will help further reduce the rear aspect RCS together with the IR signature.

Air Chief Marshal Rakesh Kumar Singh Bhadauria after taking charge of the Indian Air Force (IAF) fully backed State-owned ADA's 5th Generation AMCA program instead of Indo-Russian FGFA program based on Su-57E. National Security Advisor AjitDoval has assured Russian officials previously that India might have walked away from a joint venture to develop FGFA but is still open to procuring the Export model of Su-57 when it is ready.

DEFENCE

Budget 2020 | Meagre defence hike threatens military modernisation

A bag containing federal budget documents lie at the parliament house complex in New Delhi, on Saturday. | Photo Credit: AP

The total outlay does not include ₹1.33 lakh crore set aside separately for payment of pensions.

The allocation for defence in the Union budget presented by Finance Minister

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NirmalaSitharaman on Saturday saw a marginal hike compared to last year which does not cater to the inflation and currency exchange fluctuations. The allocation for 2020-21 stands at ₹3.37lakh crore excluding defence pensions which stood at ₹1.34 lakh crore.

UrbanUnionTransport169,637TransfertoStates200,447TaxAdministration152,962SocialRuralDevelopment144,817Pension210,682Others84,256ITandTelecomInterest708,203HomeA□airs114,387Health67,484Foodsubsidy115,570FinanceFertilisersubsidy71,309Education99,312Defence323,053AgricultureandAlliedActivities154,775

(Red denotes a fall in expenditure, while green is for an increase. The darker the red, the more the amount allocated has decreased; the darker the green, the more the amount allocated has increased)

The total allocation for defence in 2020-21 including pensions stands at ₹4.71 lakh crore compared to ₹4.31 lakh crore last year. There is a steep rise in defence pensions, 13.5%, from ₹1.18 lakh crore in revised estimates to ₹1.33 lakh crore. Excluding defence pensions, the allocation this year is ₹3.37 lakh crore which is 5.67% higher compared to the budget estimate of last year and just 1.8% higher compared to the revised estimates of 2019-20 which was ₹3.31 lakh crore.

The hike doesn't not fully cover inflation and currency fluctuations and is meagre considering the mega defence tenders recently signed and several lined up as part of military modernisation. Also, this doesn't even cover the revenue expenditure and committed liabilities in some cases as was flagged by the services after the interim budget last year.

"National security is the top priority of this government," Ms.Sitharaman said in her budget speech but there was no mention of the defence allocation in her over two hour long budget speech. The defence spending for 2020-21, excluding pensions, accounts for 1.5% of the country's Gross Domestic Product (GDP).

The hike is a worrysome scenario for the much needed military modernisation as India has signed several big ticket defence deals in the last few years and the current

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capital allocation doesn't even cater for payments to the committed liabilities. Even last year, the services had to roll on some of their committed liabilities and they would further accumulate this year.

The Indian Air Force (IAF) got 38% of the ₹1.13 lakh crore capital component which comes to ₹43,281 crore, but in real terms, the capital allocation for the IAF has gone down from the revised estimates of 2019-20 which was ₹44,869 crore. In comparison, last year, the IAF had committed liabilities, payments for deals already signed for, of over ₹47,000 crore which was more than its entire capital allocation even then. The IAF has signed several major deals including 36 Rafale jets from France, S-400 air defence systems from Russia, Apache attack helicopters and Chinook heavy lift helicopters from the US among others.

The resource constraint is likely to delay several multi-billion dollar deals for fighter jets, submarines and helicopters being processed through the Strategic Partnership model.

Commenting on the defence allocation, Commodore C. UdayBhaskar (Retd), Director of Society for Policy Studies, said two signals can be inferred from the budget. One emerges from the fact that the Finance Minister did not even mention defence allocation in her speech, which suggests that national security is clearly not a high priority, he told The Hindu.

"Second, the inventory modernisation and acquisition programs of the armed forces will be on hold for another year — and it is evident that despite all the earnest rhetoric, enhancing military capability is not on the radar for Modi 2.0 due to other considerations including the budget deficit. This will have an adverse bearing on the trans-border military capability of India which is in dire need of fiscal infusion, but this is now on hold," he said.

Finance Commission

The Services and the Defence Ministry have made a representation to the Finance Commission for additional allocation to meet the shortfall. In its interim report, the

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Commission observed that there is merit in ensuring a predictable and stable flow of funds for defence and internal security and this will receive appropriate consideration in their final report.

The interim report said that to generate additional resources, the Defence Ministry has proposed disinvestment of defence public sector undertakings, levying of a cess, monetisation of surplus land and other assets, as well as the issuance of tax-free defence bonds and the creation of a non-lapsable fund. Finance Commission will set up an expert group to examine proposals, it added. +

The total allocation for defence in 2020-21 including pensions stands at ₹4.71 lakh crore compared to ₹4.31 lakh crore last year.

Of the ₹4.71 lakh crore, ₹3.37lakh crore is revenue and capital allocation and defence pensions is ₹1.34 lakh crore.

There is a steep rise in defence pensions year on year from ₹1.18 lakh crore from revised estimate to ₹1.33 lakh crore this year.

The allocation of ₹3.37 lakh crore is 5.67% higher compared to the budget estimate of last year which was ₹3.18lakh crore and just 1.8% higher compared to the revised estimates of 2019-20 which was ₹3.31 lakh crore.

The defence spending for 2020-21, excluding pensions, accounts for 1.5% of the country's Gross Domestic Product (GDP), the lowest since 1962 war.

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Japanese warship departs for Gulf to patrol oil lifeline

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Japan Maritime Self-Defense Force (JMSDF) destroyer Takanami sails off Yokosuka, Japan, January 10, 2020, in this photo taken by Kyodo. Mandatory credit Kyodo/via REUTERS | Photo Credit: KYODO

Abe's government has said it is prepared to authorise force to protect ships in danger, a controversial decision because Japan's war-renouncing constitution forbids the use of military force in international disputes.

A Japanese destroyer left for the Gulf of Oman on Sunday amid simmering Middle East tension to guard sea lanes that supply nearly all the oil that powers the world's third-biggest economy.

"Thousands of Japanese ships ply those waters every year including vessels carrying nine tenths of our oil. It is Japan's lifeline," Japanese Prime Minister Shinzo Abe told the crew at Yokosuka naval base near Tokyo, before they cast off in a ceremony attended by 500 family members and representatives from the United States, European nations and Middle East.

Abe's government has said it is prepared to authorise force to protect ships in danger, a controversial decision because Japan's war-renouncing constitution forbids the use of military force in international disputes.

The Takanami, which will be joined by two maritime patrol planes, will not, however join a naval force led by Japan's U.S. ally or other naval coalitions in the region.

Tokyo has chosen to operate independently as it navigates disputes in the volatile region. Japan maintains cordial relations with Iran and other countries there and Abe travelled to the region in January to brief Saudi Arabia, the United Arab Emirates and Oman on the mission after earlier speaking with Iranian leaders.

Tension in the Middle East has heightened as friction between Iran and the United States escalated following U.S. President Donald Trump's decision to pull the United States out of a 2015 international nuclear deal with Iran and re-impose sanctions on it.

The United States has blamed Iran for several attacks on international merchant

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vessels, including a Japanese-owned tanker, the Kokuka Courageous. Tehran denies the accusation.

In addition to the Gulf of Oman, the Takanami, with 200 sailors and two helicopters, will patrol the northern Arabian Sea and the Gulf of Aden, but will not enter the Strait of Hormuz, a strategically important choke point between Iran and the Arabian peninsula.

The Japanese destroyer will share water in the region with a growing number of warships from other countries, including vessels from the United States, France and Britain.

"Japanese merchant ships were attacked in June, and other nations have increased patrols so Japan too is acting to gather intelligence there," the mission commander, Captain Yosuke Inaba told reporters before he departed.

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India is home to Asia's oldest bamboo

With over 49,000 plant species reported as of 2018, India holds about 11.5% of all flora in the world. Now, a new fossil record has shown that India is the birthplace of Asian bamboo, and they were formed about 25 million years ago in the north-eastern part of the country.

Ancient fossils

An international team of researchers found two fossil compressions or impressions of bamboo culms (stems) and after further study noted them to be new species. They were named Bambusiculmus tirapensis and B. makumensis - as they were found in the Tirap mine of Makum Coalfield in Assam. These belonged to the late Oligocene period of about 25 million years ago.

They also found two impressions of bamboo leaves belonging to new species Bambusiumdeomarense, and B. arunachalense, named after the Doimara region of Arunachal Pradesh where it was discovered. These leaves were found in the late Miocene to Pliocene sediments, indicating that they were between 11 and three million years old.

Yunnan Province in China now has the highest diversity of bamboo, but the oldest fossil in that region is less than 20 million years old, clearly indicating that Asian bamboo was born in India and then migrated there. This finding further strengthens the theory that bamboo came to Asia from India and not from Europe.

Wide niche

"Today, we can see bamboo in a wide range of climatic conditions from as cold as 5 degree C to even 30 degrees C. And at sea level to heights of about 4,000 metres. They can survive in varying rainfall conditions too. We wanted to know what made it develop such a wide environmental niche," explains Gaurav Srivastava, from the BirbalSahni Institute of Palaeosciences, Lucknow. He is the first and corresponding author of the paper published recently in the

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journal Review of Palaeobotany and Palynology.

Role of plate tectonics

In fact, the European bamboo fossil is about 50 million years old. Dr Srivastava explains that the Indian plate collided with the Eurasian plate about 50 million years ago. However, the suturing between the two plates were not completed until 23 million years, meaning the plates were not completely joined, restricting migration of plants and animals. And also as the Himalayas were not formed yet, the temperature was also warm and humid in the Northeastern region, with not many seasonal variations.

The present climate in the region is cold with strong winter and summer conditions. Bamboo braved these climatic and geographical changes making it the fittest in the survival race.

“Bamboo fossils are not very common in India as they are known only from the Siwalik sediments. We have planned more studies in this region and search for its fossils in older rocks too,” adds Rakesh Chandra Mehrotra, the study head from the BirbalSahni Institute of Palaeosciences.

Dr. Mehrotra adds that paleobotany is studied only in very few pockets in India. This study has shown that India is a treasure trove of plant fossils and more importance needs to be given to its study.

Decoding how plant roots regenerate

Lizards growing their lost tail, zebrafish healing its wounded heart are perfect examples of the remarkable feet of regeneration certain animals possess. Plants are known to regenerate lost tissues or organs throughout their bodies. But how to do they do it? A new research has identified a protein that helps plant roots regrow its cut tips.

An international team of researchers lead by Prof. Kalika Prasad, from the School of Biology at the Indian Institute of Science Education and Research (IISER) Thiruvananthapuram has pointed out that a protein called

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PLETHORA 2 (PLT 2) was the essential ingredient for primary and lateral root regeneration.

They studied a road-side plant of the mustard family and noticed that within eight hours of cutting its root tip, a high build-up of the protein at the site of damage. Using real-time live imaging the team was able to track the behaviour of the protein and found that the protein was distributed in the form of a gradient with the highest concentration in the root tip.

The team also noted that the entire plant root was not competent to regenerate and it was confined only to the tip of the root. They then demonstrated that by delivering the PLT2 protein, regeneration can be triggered even from non-competent root cells, which have long ago ceased to divide. They add that the protein works only at the right dose and exposure beyond the threshold was found to reduce the regeneration potential.

Agricultural benefits

"This regeneration is of immense importance to agronomically important plant species like carrot, radish or beetroot, in which the edible part is the primary root. Similar to other plants, these crops encounter damage to their primary root tips during growth and PLT2 protein can enable quick regeneration in such cases," explains KavyaDurgaprasad, Ph.D. scholar at the institute and first author of the paper published in Cell Reports.

She adds that during the early stages of plant growth, the plant relies only on the primary root and any damage if not regenerated will halt the further growth of the root, which can prove very detrimental to the plant. The newly identified protein can be used to address these issues.

Shoot system study

Aerial organs such as leaves and stems often encounter injuries and their quick repair is essential for the survival of plants. Interestingly, members of the PLETHORA proteins are known to repair such damages and allow the

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plant to restore their growth.

Currently, the team is engaged in understanding how tissues disconnected in the shoot because of injuries (such as high wind or rain) regenerate and find their paths to get reunited.

"The most important message for members of the animal kingdom such as humans, who have lost the ability to regenerate is that the secret of regeneration may not lie only in finding novel genes from animals that are capable of regenerating their organs but most importantly the regulation of existing genes," adds Prof. Prasad.

Meghalayan rainforests similar to equatorial ones

The northeastern State of Meghalaya known for its wettest districts and living root bridges is also home to a lowland tropical rainforest north of the Tropic of Cancer. A new study discovers that this rainforest, the northernmost in the world, is similar in structure and diversity to the other rainforests found near the Equator.

Rainforests usually occur near the Equator and about five degrees North and South latitudes from the Equator are considered the real home of the lowland tropical rainforest. The extreme spread of tropical rainforests in northern limits in the world has been found in northeastern region of India where high rainfall-receiving habitats with hot and humid climate, especially in Meghalaya and Namdapha in Arunachal Pradesh are now known to boast species-rich rainforests.

Stretched distributions

Uma Shankar from the Department of Botany, North-eastern Hill University set out to study the Namdapha rainforests in Arunachal Pradesh in late 1990s and in Meghalaya a few years ago. "We wanted to note how far north these rainforests extend and how different they are from the ones found near the

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Equator," he adds. "Decoding what were the precursors for their stretched distribution in this region was also an interesting task."

The team found that the climatic conditions in the region — high rainfall and humidity, and perfect annual mean temperature — were conducive for the survival of the rainforests. Since rainforests have a complicated structure, the team looked at over two hectares of forest area, studying nearly 2,500 individuals including trees, shrubs and herbs. Over 180 different taxa were identified of the total, and it was noted that tropical Asian species made up 95% of the abundance. Although these rainforests had fewer species and individuals of liana or woody climbing plants, the levels of beta diversity were high. Also compared to Equatorial rainforests, they had a higher proportion of rare species and good representation of the members of families of Fagaceae and Theaceae in the Meghalayan rainforests.

Shorter trees

The results published recently in Plant Diversity note that though the species diversity was similar to the other rainforests, the Meghalayan rainforest trees showed short stature. While the trees in the Equatorial region are known to grow from 45 to 60 m in height, the highest ones in Meghalaya could reach only up to about 30 m. Dr. Shankar adds that in order to survive at this higher latitude the trees would have to make some compromises.

The region had a high density of 467 trees per hectare. Though this is lower compared with equatorial rainforests, it fell in the intermediate category for rainforests around the Tropic of Cancer. Also, the richness of species per hectare was the highest among all lowland rainforests near the Tropic of Cancer.

Ignored in maps

Though it has so many special aspects, the team writes that this region has been virtually ignored on the world maps of tropical rainforests.

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But recent developmental and tourist activities have started to degrade patches of these rainforests.

Pesticide exposure among tea estate workers could affect their DNA

In the lush tea gardens of northern West Bengal, hundreds of men and women go about their daily business. But lurking here is a hidden danger they are unaware of — pesticide exposure, which is a growing global concern today. Susmita Dutta from the University of North Bengal, set out to investigate this problem in the tea gardens of Darjeeling foothills as a part of her doctoral research.

Two reports recently published by the team points out that chronic exposure to the mixture of pesticides has led to changes in the DNA and also decreased certain enzyme activity.

Enzyme activity

The team collected blood samples from over 200 individuals which included estate workers, controls who didn't smoke or drink and two more control groups who either smoked or consumed alcohol.

Detailed analysis showed that the estate workers both men and women, irrespective of whether they smoked or consumed alcohol, showed decrease in enzyme activity, especially enzymes AChE and BuChE.

"AChE is known to be target of most organophosphates. AChE terminates synaptic (neuron to neuron) transmission, preventing continuous nerve firings at nerve endings. Organophosphorous pesticides bind to this site and inactivate the enzymes. In the long run, these may even cause other neurological complications. Some studies have pointed out that herbicide and fungicide exposure is associated with Parkinson's disease too," explains Dr. Dutta, the first author of the paper published in Biomarkers.

Another paper published by the team in Mutation Research – Genetic

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Toxicology and Environmental Mutagenesis, shows that pesticide exposure led to DNA damage.

Comet assay

The team used a special study called comet assay which helps assess DNA damage and found that individuals exposed to pesticides had significantly higher value of certain parameters which suggest damage compared to control subjects.

The paper notes that the damage might be the due to single strand DNA breaks, or any disorder of the DNA or DNA-DNA or DNA-protein cross-links. This damage was found to be independent of sex, age, or duration of exposure.

The researchers note that the workers were not wearing any protective gear such as masks, gloves and boots. The men who were mostly sprayers inhaled and also contacted the pesticide through their skin. The female workers also came into direct skin contact and has residues on their clothes.

Preventive measures

The team also warns of second-hand contact where the family can also be exposed if the workers don't clean up properly before going home.

Dr. Dutta adds that this problem is prevalent in all plantations across the country and to prevent further health problems for this workforce they need to be educated to take safety precautions.

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Light and shade in photosynthesis

Yes, photosynthesis will be less in leaves that are in shade. Usually they will not be in permanent shade, there will some light falling on them at some time of the day, also due to wind the leaves will get light.

The leaves in shade will adapt to shade. One of the adaptions of these leaves that are in shade is to have larger area to capture more light for

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photosynthesis.

These leaves are thinner than the leaves that are open to the Sun. The shade leaves are dark green in colour and also the chloroplasts and the light harvesting complex moves within the cells to places where there can be more light interception. The shade leaves are more efficient in photosynthesis, the problem is that they lose more water by transpiration at the same temperature and humidity conditions.

The shade leaves also have low dark respiration rates and hence fewer light compensation points – which is the light intensity on the light curve where the rate of photosynthesis exactly matches the rate of cellular respiration – this is low for leaves in shade. These adaptations take place during the development of the leaves. Leaves in shade also have short and long term strategies to count fluctuating light intensity.

The short term strategy is rearrangement of antennae system in photosystems in the leaves so that they can make use of the available light effectively.

This is done by movement of the mobile pool of the light harvesting complex in the photosystems.

The long term strategy of the leaves in the shade is to overexpress some of the genes of Photosystem I – psaA, psaB and Photosystem II – psbA.

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NPL synthesises novel security ink

A novel security ink that emits intense red colour when exposed to 254 nm wavelength UV and emits green colour soon after the UV source is turned off has been synthesised by a team of researchers from the Delhi-based National Physical Laboratory (CSIR-NPL). The emission of red is due to fluorescence while green is due to phosphorescence phenomenon. Both red and green can be clearly seen with the naked eye under ambient conditions.

The red colour is emitted at 611 nm wavelength while the green is emitted at 532 nm. The ink has the potential to be used as a security feature on currency notes and passports.

Two pigments

"To the best of our knowledge, this is the first report of an ink that contains two pigments that emit different colours at very different wavelengths when exposed to UV light of a particular wavelength," says Dr. Bipin Kumar Gupta from NPL who led the team of researchers. The results were published in the Journal of Materials Chemistry C.

Unlike in other materials, the ink shows phosphorescence as the emission of the red pigment is not quenched by the green pigment while the UV lamp is on as the two have very different emission wavelengths — 611 nm for red and 532 nm for green. Also, when exposed to 254 nm UV light, the excitation spectrum of one does not cover the other.

Hydrothermal processing

The team first synthesised the pigments that emit red and green colours. For synthesising the red pigment, sodium yttrium fluorite doped with europium through hydrothermal method. For the green pigment, the researchers mixed strontium aluminium oxide and doped it with europium and dysprosium.

"We have to use two dopants for the green pigment as continuous generation of photons is needed for phosphorescence. In this case, the europium provides the electrons while dysprosium provides the holes. The electrons and holes recombine

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to create photons," explains Dr. Gupta.

The red and green pigments synthesised separately are mixed in 3:1 weight ratio and heated to 400 degree C for three hours. "Annealing [heating] at 400 degree C ensures that the rods [of sodium yttrium fluorite red pigment] adhere to the spheres [of the strontium aluminium oxide green pigment]," says Dr. Gupta. "If the two pigments are mixed without annealing then the two pigments would separate out during ink formation and the desired property of the ink to produce dual emission with single excitation will not be possible."

The ink is prepared by dispersing the two pigments that have been mixed at a high temperature in a commercially available polyvinyl chloride (PVC) medium and vigorously stirred for an hour.

"The advantage of having the rods sticking to the spheres is that the rods don't cover the spheres completely and so both the pigments are exposed to UV irradiation," says Amit Kumar Gangwar from CSIR-NPL and first author of the paper. "In the core-shell structure that we tried, the shell tends to block UV excitation and so the emission from the core is reduced."

Lasting phosphorescence

While the green phosphorescence is seen even if the ink is briefly exposed to UV radiation, exposing the ink to UV for 15 minutes ensures that the phosphorescence lasts for about four hours.

The researchers found the images printed on ordinary paper using the ink exhibits excellent physical durability and chemical stability. There was no noticeable change in emission from the images even at the end of six months when exposed to high (42 degree C) and low (10 degree C) temperatures and high humidity. The emission showed no changes when the images were exposed to various bleaching solutions. "We carried out accelerated testing and found that the images to be stable for more than 20 years," says Dr. Gupta.

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How insects, pests wipe off Ajanta cave paintings

A classic masterpiece of Buddhist art, the Ajanta caves, is a UNESCO world heritage site and a protected monument of the Archaeological Survey of India. But the cave paintings have started deteriorating in the past few decades and are losing the battle against insects and other climatic stressors.

A research team from National Environmental Engineering Research Institute (CSIR-NEERI) looked at all the available literature on the Ajanta caves and mapped out the different factors causing this damage. They also mention a few environmentally friendly solutions to the problem in a paper recently published in Heritage.

The team writes that the most common insects were silverfish, beetles and common bugs. Another main problem was the entry of rainwater and water from the Waghura River. This leads to dampness in the cave atmosphere causing an increase in algae, fungi, insects, and microbes. All these together were changing the original colour of the paintings — white is turning to yellow and blue is becoming green.

Why microbes thrive

The paper notes that “a mixture of hemp, clay, and lime plaster was considered efficient for preserving paintings and carvings in nearby Ellora caves,” but this method was not used in Ajanta caves. Previous studies have shown that the basal layer of the murals was made of mud plaster and organic matter such as paddy husks, grass, vegetable fibres, thus making it a good breeding place for microbes and insects. Even though ASI has started many initiatives to keep bats and pigeons from the caves, it has failed and bat and bird excreta continue to damage the paintings.

Light to the rescue

The researchers have suggested using certain lights and colour to tackle the problem of insects. For instance, they suggest using ultraviolet light traps as nocturnal insects are known to get attracted to ultraviolet radiation. Also many diurnal species move to yellow light traps so yellow lamps can also be an excellent tool to effectively control moths. By understanding the phototactic behaviour of insects, appropriate wavelength lights can also be used. “Based on the details collected from past studies, we are

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developing a prototype to address this issue. As it is in the initial stages, more details cannot be disclosed," says Mr. Piyush Kokate, from the institute and one of the authors of the paper.

ASI is presently carrying out precautionary treatments such as spraying of insecticides and herbicides, fixing the loose plaster on cave walls, regular cleaning and use of preservative coating on the painting.

Blue lights leads to aging

Prolonged exposure to blue light, such as that which emanates from your phone, computer and household fixtures, could be affecting your longevity, even if it's not shining in your eyes. Blue wavelengthsproduced by light-emitting diodes damage cells in the brain as well as retinas, according to a new study in a model organism.

Understanding upside-down landings of flies

"When I was a student, Late Prof. K. S. Krishnan who was on the interview panel asked me, 'how do flies land on the ceiling?' Although seemingly an innocuous question, it turns out to be a really complex phenomenon," says Prof Sanjay Sane from the National Centre for Biological Sciences, Bengaluru. Now, after several years of research using the modern state of the art tools and months of video recordings his team has answered the question. The paper recently published in Science Advances notes that the inverted landing "involves a serial sequence of well-coordinated behavioural modules."

Four steps

The international team lists out four steps that take place in the complex process which includes upward acceleration towards the ceiling and then based on visual inputs it begins to rotate - pitch and roll. It then flings all six legs and prepares to land, and in the final stage does a leg-assisted body swing and lands firmly.

Precision landing

The question is how is it possible to do all the four steps so precisely. It involves

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visual, neurobiological and gyroscopic inputs. The team used video recordings of how blue bottle flies land and by plotting the distance at which landing is initiated and speed at that point, they concluded that they have to initiate deceleration at 40 microseconds speed. For easy comparison, we blink our eyes at about 150 to 200 microseconds. If the fly missed initiating the landing response within this window, it ended up colliding with the substrate.

The team from NCBS had previously compared how houseflies land on the straight wall and inverted ceiling. The results published earlier this year in PLOS ONE noted that in both cases, the fly uses the same landing manoeuvres but there are also notable differences in both types of landing.

Difficult task

"To orient itself in an inverted position, a fly can either perform a roll rotation or a pitch rotation or a combination of both," explains Sujay Acharya, the first author of the paper from NCBS in an email to The Hindu.

"Vertical landings on the other hand are highly stereotyped. As the fly approaches the wall, it pitches up before contact. Our data also indicates that ceiling landings may be more 'difficult' for a fly. We observed that in close to half the cases, a fly landing on a ceiling bumped into it. Whereas, we did not observe such collisions for vertical landings."

Prof. Sane adds that, "This study will help us gain insights into how the nervous system acquires and integrates inputs from multiple sensory modalities to execute a fast but precise behaviour." He also explains that these flies belong to the Dipteran order which means they have only one pair of wings and their hind wings are modified into special structures called halteres, which helps in body orientation and alerts them when they are involuntarily pitching or rolling.

Inspired by nature

"We look at nature for inspiration. This helps drive the fundamental science of engineering, to understand how flies are able to solve these problems so we can apply them to future technologies," explains Prof. Jean-Michel Mongeau, one of the

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authors from Pennsylvania State University in a release. “This work reiterates how fast these [manoeuvres] are executed within an extremely small nervous system. This data can lead to new hypotheses for understanding how brains function.”

Collapse of ancient civilisation linked to megadrought

The Neo-Assyrian Empire — that thrived between 800 and 600 BCE centred in northern Iraq, extending to Egypt — may have collapsed due to a 60-year, climate related megadrought, according to a study.

The researchers, including Indian-origin scientist Ashish Sinha at California State University in the U.S., said the Neo-Assyrian Empire was by far the largest empire in the region up to that time, controlling much of the territory from the Persian Gulf to modern day Cyprus.

The study, published in Science Advances, noted that climate-related factors contributed to political instability, civil wars, and invasion by outside armies, that ultimately led to the civilisation’s collapse.

The researchers said the Neo-Assyrian Empire experienced a series of megadroughts that probably triggered its collapse by weakening agriculture and amplifying conflict.

They analysed fossilised drip water in the Kuna Ba Cave in northern Iraq and assessed the quantities of radioactive isotopes, or variants, of oxygen and carbon atoms present across different layers of the cave formations to infer historical time based on changes in precipitation.

“Because the isotope record went all the way up to 2007 CE, we were able to correlate the stable carbon and oxygen isotope ratios with modern instrumental climate information from the region. This has enabled us to compare the modern isotope data with ancient layers,” Adam W. Schneider, study co-author from University of Colorado, Boulder, explained.

The researchers found that the megadroughts that affected the empire started decades earlier than previously thought,

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Climate-related factors have contributed to the collapse of several empires in history.

Music is humankind's universal language: study

Songs spanning different languages and ethnic groups across the world exhibit common behavioural patterns, according to a first-of-its-kind study which suggests that human culture everywhere is built from common psychological building blocks.

The study, published in the journal Science, reports the first comprehensive scientific analysis of the similarities and differences in the types of music produced by various ethnicity around the world.

It looked at more than a century of research on the historical and cultural context of music, or ethnomusicology, of more than 300 societies across the globe.

The researchers from Harvard University in the US collected hundreds of music recordings in libraries and private collections of scientists half way across the world, culminating in around 5,000 song descriptions from 60 cultures spanning 30 distinct geographic regions globally.

They analysed the discography in four different ways — machine summaries, listener ratings, expert annotations and expert transcriptions.

The results of the study revealed that across societies, music is associated with behaviours such as infant care, healing, dance, love, mourning and warfare.

According to the researchers, these behaviours are not too different between societies.

While examining lullabies, healing songs, dance songs, and love songs, they found that songs sharing similar behavioural functions had common musical features.

"Lullabies and dance songs are ubiquitous, and they are also highly stereotyped," study co-author Manvir Singh said.

"For me, dance songs and lullabies tend to define the space of what music can be. They do very different things with features that are almost the opposite of each other," Singh said.

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According to Singh, the distinct similarity in the music produced by different societies is evidence that human culture everywhere is built from common psychological building blocks.

The researchers said the study may also help unlock the governing rules of "musical grammar."

How we learn new languages: songbirds offer insight

We humans have used other animals as models to understand our own biological features and their mechanisms. The common fruit fly has been used for identifying several genes and how mutations in them are related to physiological and biochemical defects. Many of the genes in the transparent worm called C. elegans have functional counterparts in humans. Mice, rats and rabbits are somewhat "higher" animals and have offered us even greater insights. Such model organisms are easy to maintain and breed in the lab and can be studied right from their birth, adulthood and through their lifetime in short spans of time.

But when it comes to understanding the brain and the neurological basis of some actions, in particular, how we speak, sing, imitate and learn foreign words and languages, the above models are not the best. Some have tried using our closest ancestors, such as chimpanzees, in order to understand how they speak, sing or learn other words, but alas, with little success. Two psychologists (C & K Hayes) adopted a baby chimpanzee at their home, brought it up as a child and tried to teach this little girl chimp (called Viki) to speak human language. Alas, besides trying to say "mama", "papa", "up" and "cup", Viki could do nothing more. The gradual shaping of her jaw and lips (as she tried hard) allowed her to utter these words, nothing more. It appears that the neural and physiological set up which she had, Viki could only utter chimp sound but not imitate humans. Likewise, another couple (the Gardners) had bred a chimp (called Washoe) at home, and she did a little better than Viki, in that she could do learn a 'foreign' language (not spoken but gestural), namely the American Sign Language (ASL), in which she could learn as many as 350 ASL

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signs and respond to some questions in this non-verbal language. It would thus appear that the necessary anatomical vocal 'hardware' is inadequate here, though the 'software' to learn is developed somewhat in chimps. We, their descendants, are blessed with the right hardware and software.

Animal models

Thus in looking for animal models for understanding how we speak, sing, imitate and learn 'foreign languages"— and such brain-based activities — we need to go back in evolution and see which animals have been doing these activities, and which parts of their brains are involved in these, and look for similar features in the human brain. And the best animals models used so far are songbirds such as parrots, mynahs, finches, hummingbirds and such. For example, some of us keep parrots as pets at home and find that they not only utter their own words, calls and species songs, but also learn to mimic our sounds and words, and "talk" human language. This shows that, these songbirds have parts in their brain which play a key role not only in the normal vocal development which helps them in learning to speak/sing their own 'species' language (the normal genetically programmed ones from their parents), but also to imitate those of others. This has offered some insight and parallels with our own vocal development of learning to speak, sing and so forth.

An early summary, well worth reading, is from Peter Marler in the journal American Scientist; 1970:58:669-673, available online. While all animals, cats or chimps are programmed to learn and vocalise their own species language (grunts, gestures and such), learning and imitating is done by songbirds which arose 250 million years ago, and us humans, who came on earth only 2-3 million years ago.

How songbirds learn

Songbirds learn their species language, just like other animals do, by imitating the sounds of older members of their own species. This they do by modifying their voices such that they match what they have memorised. A newborn songbird starts with a babbling voice and sounds, which in a few weeks, turns to the language of the species; in other words, this "subsong" becomes the "song" of the species language.

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Note, too, how a newborn human infant babbles, which turns into human language — the language spoken at home by its parents and family members.

F. Nottlebohm, in his review article on the neural basis of birdsong (PLoS Biology, 2005; 3(5):759-761; e16) points out that there is a group of discrete brain areas (called nuclei) and their connecting pathways, referred to as the song system or song nuclei. In hummingbird brains (likewise in other songbirds, such as parrots) there are 7 discrete structures which are active during singing, showing that these are the anatomical and functional 'vocal nuclei'. In such vocal learning birds, the brain's forebrain region appears divided into two sub-pathways: in a vocal motor pathway used to produce learned vocalization, and the other, a loop, that allows the modification of these 'songs'. We humans too have similar forebrain pathways (Davis, J. Ornithol. 2007; 148(1); 35-44).

An interesting work, in this connection, has appeared from a Japanese group in Hokkaido, this month (Wang et al., PLoS Biology 17(11): e3000476;htpps:doi.org/10.1371/journal.pbio.3000476). They studied the singing pattern of two finches — zebra finches (abbreviated as z) and owl finches (o), and studied the genes that are expressed in the song nuclei of each of them. There was about 10% difference in the expression of the genes, leading to different species songs that they sing. Next, they crossed the two species and produced two hybrids (zo, and oz, depending on which male crossed with which female), and recorded their songs. The zo hybrid sang both her parents' species songs, the zebra finch song and also the owl finch song; likewise the hybrid oz sang the owl finch species song, plus the z song! More such inter-species hybrids would offer additional insights, though we cannot do so with humans (ethical considerations)!

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Fossil reveals how middle ear evolved

Researchers have unearthed well-preserved middle ear bones from a new species of an extinct rodent that lived 145-66 million years ago in what is now northeastern China, an advance that may lead to better understanding of the evolution of

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hearing.

The study, published in the journal Nature, looked at fossils of the extinct rodent-like mammal — Jeholbaatar kielanae — at Jehol Biota of China, and noted that these animals had a middle ear that is distinct from those of its relatives.

The researchers, including those from the Chinese Academy of Sciences, said the evolution of the rodent's bones and muscles involved in hearing may have been driven by specialisation for hearing. They said the fossil clues provide solid evidence of the morphology and formation of the inner ear bones, which are fully detached from the lower jaw.

Unique configuration

According to the researchers, the bones reveal a unique configuration with more complete components than those previously reported in these creatures.

The new fossil, they said, reveals a transitional stage in the evolution of the surangular — a "reptilian" jawbone.

Based on the new findings, the scientists speculated that in a class of extinct mammals, the joints connecting the middle ear to the eardrum, and those connecting bones in the cheek region to the lower jaw may have evolved in tandem, allowing a distinct jaw movement while chewing.

They suggested that in these extinct mammals, the evolution of the middle ear may have probably been triggered by functional constraints on the bones and muscles involved in feeding.

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Evidence of river Saraswati's existence found?

The Indus valley civilisation which flourished in present day northwestern India and adjacent Pakistan was the largest and oldest urban civilisation in the world. Nearly two-thirds of the 1,500 archaeological sites of the Harappans occur on the dried up banks of the Ghaggar river. Today, the Ghaggar is a seasonal, monsoon-fed river originating in the sub-Himalayas. The question arises about the role played by the Paleo Ghaggar, ancient counterpart of this river, in the lives of the Harappans. Did

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the Harappans live on the banks of a perennial river, mighty and fed by the glacial rivers arising in the Higher Himalaya, or was Paleo Ghaggar also a monsoon-fed and seasonal river that rose in the sub-Himalaya?

These questions are tied to another. The Rig veda mentions a mighty, snow-fed river Saraswati on whose banks the literature was supposed to be derived. Was this then a description of the Paleo Ghaggar, making it the mythological Saraswati River itself? These questions are sought to be answered in a paper published in Scientific Reports.

Researchers from Physical Research Laboratory (PRL), Ahmedabad, and Indian Institute of Technology Bombay, have analysed sand from 3-10 metres below surface of modern Ghaggar and found that it was indeed a perennial river, fed by glacial rivers in the past.

Finding the source

"Coarse-grained white or grey sands that contain abundant white mica are typical of glacier-fed Higher Himalayan rivers such as the Ganga, Yamuna and Sutlej... We found such sand layers 3-10 metres below the surface on both sides of the modern Ghaggar in a stretch of 300 kilometres up to the Pakistan border," explains Jyotiranjan S. Ray of PRL. "Presence of this sand itself is an indication of existence of a powerful river in the past."

The team identified the source of these sands by studying the strontium-neodymium isotopic ratios. They also measured the ages of the mica samples in the sand by argon-argon dating method. "We found that the isotopic ratios and Ar-Ar ages overlap with those of the rocks of the Higher Himalaya, thus we establish that these sands have been transported by the river from Higher Himalaya to the plains," says Dr Ray.

Further, the team established the depositional ages of the samples by radiocarbon dating and optical dating of mollusk shells found in the deposit. The researchers thus established that the ancient Ghaggar transported sands from glaciated regions of the Higher Himalaya. "Any river that originates from such region remains active

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round the year – doesn't depend on the monsoonal rains only," explains Dr Ray.

The key result of the paper is that the river Ghaggar had two distinct perennial phases: one during 80,000-20,000 years ago and the other during 9,000-4,500 years ago.

Early, late Harappans

"The paper contains excellent isotopic geochemical data on the sediments of the river Ghaggar. On the basis of their data the authors show that the Sutlej River was flowing into the Ghaggar River to make it perennial for the Early Harappans," says Jayant Kumar Tripathi of School of Environmental Sciences, Jawaharlal Nehru University, Delhi, who is an expert in the field. In a 2004 paper in Current Science, he has studied the later phase of the river Ghaggar. "However, what made mature Harappans to stay back on the Paleo Ghaggar, remains unanswered in their paper," Prof. Tripathi adds commenting on the recent work.

The authors write in the paper that the revived perennial condition of the Ghaggar, between 9,000 and 4,500 years ago can be correlated with the Rig vedic Saraswati, and that it "likely facilitated development of the early Harappan settlements along its banks".

Study pushes back evolution of speech by 20,000 years

Researchers have shown that monkeys produce well-differentiated proto-vowels, an advance that pushes back earlier estimates of when speech evolved in animals by about 2,00,000 years.

The review study, published in the journal Science Advances, mentioned the theory of the "descended larynx", according to which the larynx —commonly called the voice box — must be in a low position to produce differentiated vowels before speech can emerge.

According to the researchers, including those from CNRS in France, monkeys, which have a vocal tract anatomy similar to humans, had a higher larynx, and could not produce differentiated vocalisations.

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Considering the acoustic cavities formed by the tongue, jaw, and lips (identical in primates and humans), recent research showed the production of differentiated vocalizations is not a question of anatomy, but is related to the control of articulators.

According to the current study, if the emergence of articulated speech is no longer dependent on the descent of the larynx —which took place about 200,000 years ago — scientists can now theorise much earlier speech emergence.

The researchers said this could be as far back as at least 20 million years, a time when our common ancestor with monkeys lived, and already presumably had the capacity to produce contrasted vocalisations.

Last stand of Homo erectus may have been on Indonesian island: Study

The last known settlement of Homo erectus, direct ancestors of modern humans, who disappeared around 4,00,000 years ago, was situated in Ngandong on the Indonesian island of Java, a new study published in Nature finds. According to the researchers, the human ancestors existed on the Indonesian island between 1,08,000 and 1,17,000 years ago.

Safety of buildings on stilts

Q. Are buildings with stilt parking (without a wall joining the stilts) at greater risk of collapsing due to earthquake?

Prof. Devdas Menon

IIT MadrasIn general, yes — unless the buildings have been designed structurally to mitigate the risk. Typically, in multi-storey, reinforced concrete framed buildings on stilts, masonry infill walls (between columns) are present in all upper storeys, except in the ground storey. This introduces a sudden reduction in lateral stiffness in the building in the open ground storey, relative to the upper storeys, under the action of lateral loads during earthquake.

The lateral inter-storey movement (‘drift’) in the ground storey is likely to be very

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high, compared with the upper storeys, inducing local high stresses in the ground storey columns. In an extreme seismic event, the vertical steel reinforcement can yield at the top and bottom locations of the ground storey columns, making the building vulnerable to a 'soft storey mechanism' collapse: the building can simply 'cave in', with the upper storeys coming down. (flattening the cars parked in the ground storey — as witnessed during the 2001 Gujarat earthquake).

Such sudden failure can be avoided by proper structural design such as providing reinforced concrete shear walls at appropriate locations, or at the very least, adequately stiffening and strengthening the ground floor columns. Existing open ground storey buildings most at risk can be retrofitted to make them safe.