

News for Jan-Mar 2018

SCIENCE AND TECH.

THE CRUX OF THE HINDU

Vol. 13

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News of Jan-Mar18

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Contents

Space.....	4
Atomic Energy.....	11
Environment and Ecology.....	20
Health and Medicine.....	33
Bio-Technology.....	47
Computer and IT.....	61
Agriculture.....	67
Defence.....	68
Miscellaneous.....	71



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

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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Science and Tech.

The Crux of The Hindu

Vol. 13

News of Jan-Mar18

SPACE

Turf wars with ISRO stall connectivity: DoT official

India built the cheapest satellites but had the most expensive bandwidth, a government official said, blaming turf wars between the Indian Space Research Organisation (ISRO) and the Department of Telecom (DoT) for delays in taking connectivity to far-flung areas.

DoT's special secretary N. Sivasailam also flagged issues of costs and said the ISRO should do more in order to keep the charges on par with global experience.

Mr. Sivasailam said more transponders were required on satellites.

According to him, there is a "problem of domains" between the DoT and the ISRO that has impacted the roll-out of connectivity in far-flung areas for 20 years.



"The problem is of domains. We (DoT) don't want to leave our domain. ISRO doesn't want to leave its domain. It is a domain-related problem...I do not see people coming together and negotiating this aspect out," he said.

'It's hurting businesses

Admitting that there was "politics" which "makes things difficult", Mr. Sivasailam pitched for both the agencies getting over the problems for the benefit of all. "It is time it stopped because it is hurting business development and ultimately people are not getting (benefited)," he said, speaking at the annual FICCI Frames.

On the critical issue of costs, he said it would cost around Rs. 150 to serve one user with the current cost structure in the country whereas in the U.S., it cost \$1 or Rs. 65.

"If the U.S. is getting it for USD 1 for the same bandwidth for the life of the satellite, I should be getting it at the same rate. There is no reason why it should not happen in India. That is my refrain," he said.

Conceding that ISRO helped take satellite connectivity to 5,240 far-flung locations in the country, including 4,300 in

the Northeast, Mr. Sivasailam said the cost of the satellite, bandwidth and spectrum made "operations unviable." "If you have the volume of business, we should be able to provide at the rates internationally available and that is a matter of some concern for us. We have been working on it but not necessarily successful on this," he said.

Meteorite may hold clue to life's origin

A study of two meteorites, which fell in Assam and Rajasthan over a span of 13 hours in 2017, by the Geological Survey of India (GSI) has concluded that they may contain "significant clues to the origins of life.

Late on the evening of June 5 last, a meteorite weighing 3.014 kg fell in NatunBalijan village in Tinsukia, Assam. Thirteen hours later, early on June 6, another meteorite, weighing 2.23 kg, fell in Mukundpura village under Sadiya subdivision near Jaipur.

Experts from GSI's Meteorite and Planetary Science Division (the custodian of meteorites) studied both objects for over 10 months.

"The Mukundpura one is a carbonaceous meteorite, one of the most primitive types. They contain grains of calcium and iron, which date to a time before the sun came into existence. They may contain clues to the formation of early life," a scientist at GSI told The Hindu.

The impact of the meteorite, which fell on sandy farmland, created a hole six inches deep, with a diameter of nearly 43 cm. The GSI now refers to the object as 'Mukundpura carbonaceous meteorite.' The GSI says this is a rare type of meteorite, since carbonaceous meteorites constitute only 3%-5% of all meteorite falls. Analysis has also revealed the presence of water-bearing minerals in the meteorite.

The GSI report says the meteorite is "believed to have the most pristine primordial matter recovered from space, which might carry important clues to the origin of early life."

Meteorites mostly originate from the asteroid belt between Mars and Jupiter.

The meteorite that fell in NatunBalijan in the flood plains of LohitRiver, has been classified as an "ordinary chondrite."

According to the National Aeronautics and Space Administration, this is the most common type of meteorites, made of small grains of rock and believed to be mostly unchanged since the formation of the solar system.

GSAT-6A to give armed forces a shot in the arm



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

GSAT-6A, the second predominantly S-band communications satellite, is set to be launched from Sriharikota on March 29.

It will complement GSAT-6, which has been orbiting since August 2015 at 83 degrees East longitude. The 2,000-kg-class 6A, costing about Rs. 270 crore, is a great deal more than a routine communications satellite. It is designated for the use of the Armed Forces and will not add any transponder capacity for general uses, according to sources in the Indian Space Research Organisation (ISRO).

A special feature of the GSAT-6A is its 6-metre-wide umbrella-like antenna, which will be unfurled in once it is in space. The antenna is thrice as broad as the antennas generally used in ISRO satellites. It will enable mobile communication from anywhere via hand-held ground terminals. Regular communication satellites with smaller antenna require much larger ground stations, said a former director of ISRO.

The S-band's antenna was developed by ISRO's Space Applications Centre, Ahmedabad. The unfurl-able antenna, hand-held ground terminals, and network management techniques could be useful in future satellite-based mobile communication applications. GSAT-6A will also have a smaller 0.8-metre antenna for communication in the C band. GSAT-6A is slated to be launched at 4.56 p.m. on a GSLV rocket.

GSAT-6A gives India bigger eye in the sky

The Indian Space Research Organisation (ISRO) successfully placed a communication satellite GSAT-6A in a geosynchronous transfer orbit. It was carried on board the GSLV F-08 from the Satish Dhawan Space Centre here.

The GSAT-6A is a communication satellite that incorporates the high-thrust Vikas engine. It will complement the GSAT-6, which is already in orbit. The GSAT-6A's antenna has a diameter of six metres — it can be unfurled and opened like an umbrella once it reaches its prescribed orbit.

The ISRO team at Mission Control appeared pensive waiting for the indigenous cryogenic upper stage to fire and take the satellite into its initial orbit. Former Chairmen of ISRO, K. Radhakrishnan and A.S. Kiran Kumar, too, watched the proceedings from Mission Control.

"These two satellites combined will provide platforms for development of advanced technologies such as the unfurlable antenna, hand-held devices, and ground net-

works," K. Sivan, Chairman, ISRO, said after the satellite was placed in an initial orbit of a perigee of 170 km and apogee of 35,975 km, 18 minutes after the rocket blasted off at 4.56 p.m.

The satellite will be placed at a height of 36,000 km in a geostationary orbit, and the antenna will be unfurled in the coming days.

'ISRO needs 4 years to catch up with satellite demand'

It has been a meteoric journey from a small farming village, Sarakalvilai, in Kanniyakumari for K. Sivan, who has taken charge as the Secretary, Department of Space, and Chairman of the Space Commission and the Indian Space Research Organisation. Just days after taking on new responsibilities, Dr. Sivan shares his plans for ISRO's stepped up launch schedule and steps towards manned space flight.

You have just taken charge as Secretary, Department of Space, and Chairman, ISRO and the Space Commission. In the country's space programme which area do you think needs immediate attention?

We now have 43 satellites in space — for communication, earth observation and navigation. To meet the present national requirement, we need an equal number of satellites in addition. The frequency of launches must definitely increase. With the present launch capability, it will take us four years to make the required satellites and launch them. By then we would need to replace a few [older] satellites. It is like trying to catch up with a moving bus! This gap can be met only by increasing the launch frequency. Our aim is to meet the immediate requirement and for that, we have set 18 launches per year as the target.

For over a decade now, ISRO has been facing a serious shortage of satellite transponders. How will you tackle the gap?

Yes, we are really short of around 100 transponders. But we are going to manage that with the new satellites that we will launch. We hope to bridge the gap very soon. One major satellite that we plan to launch in a couple of months is GSAT-11. It is around six tonnes [6,000 kg]. Once it is launched and starts working, most of our problems should be solved. It is getting ready and a launch date is not fixed.

We will launch it from Kourou [in French Guiana, South America].

Do you see a need to change or re-focus activities related to development of launch vehi-



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Science and Tech.

The Crux of The Hindu

Vol. 13

News of Jan-Mar18

cles, satellites and infrastructure?

There is really no need to change anything. In ISRO we define our priorities and requirements very clearly and well ahead. We have a clear plan up to 2025 for launch vehicles and spacecraft. Beyond that, too, there is an outline as to which way we should go. We have a three-year action plan.

Which missions are coming up this year?

As a part of the three-year short-term action plan, immediate missions that we plan to do this year are the GSLV-F08 that will launch the GSAT-6A communication satellite [around February]. Then we will have a PSLV mission with navigation satellite IRNSS-1I. Then comes the second developmental flight D2 of GSLV-MkIII. It will launch the high throughput satellite GSAT-29. Later, GSAT-11, which will be our heaviest satellite as of now, will be launched from Kourou. The Chandrayaan-2 mission will be launched this year on another GSLV.

At what stage are some of ISRO's ambitious projects — the semi-cryogenic launch vehicle and the human space flight?

For the semi-cryogenic launch vehicle, the engine development is going on. Some critical [sub-systems] are getting fabricated or tested. Our target is to test fly it sometime in 2019.

The human space flight is really not in our approved programmes for now. Before it is taken up, a human mission requires many technologies. We should develop them and be ready to execute it in a shorter period. For example, the crew module shaping, certain thermal systems and the CARE (Crew Module Atmospheric Re-entry Experiment) that was tested in a partial flight of the GSLV-MkIII in 2014.

In the case of any disaster, there should be an emergency plan to rescue the crew from the capsule. One such experiment called 'pad abort' will be taken up this year. Studies related to life support systems, space suits, cabin pressure, oxygen levels, crew hygiene etc. should be completed.

Last year, a plan was initiated to entrust the entire production of PSLV launchers to industry. A similar plan is under way to produce satellites. What is their status and how will this plan help?

The process is on to give the major chunk of PSLV production to industry. Internal committees are looking at how to make work packages [i.e. distribute tasks.] The selection process is on. The first PSLV from industry should roll out in 2020. If this happens, it will take care

of half our job. More people in ISRO will be available for doing R&D.

Of the target of 18 launches per year, we would like to do 12 to 13 PSLVs, of which a major chunk would be through industry; three GSLVs and two GSLV-Mark IIIs.

Except for defining the modalities, which will take time, I would say that it should not be an issue for us. Major industries such as HAL (Hindustan Aeronautics Ltd.) L&T, Godrej and MTAR have been already contributing to our programme in big ways.

Beyond these, we are developing a new launch vehicle to put small satellites to space.

We want to hand over its technology and production to industry right from the beginning after doing one or two technology demonstration flights. We will do this through [ISRO's business entity] Antrix Corporation.

When will public services based on the Indian regional navigation constellation NavIC begin?

This is an area of priority for me — to make micro and miniaturised NavIC receivers and see that they get into our mobile phones. I am very clear about it — that any mobile without NavIC receivers will not be allowed to be sold. How we can cajole industry to do this will take time. How is NavIC itself faring? All three atomic clocks on one of its satellites, IRNSS-1A, are said to have failed. Its replacement satellite IRNSS-1H was lost at launch last August.

For NavIC's functions, four satellites are enough to get data.

Beyond four, the accuracy of giving location on ground beyond 20 metres will increase. We did want to put the replacement satellite but the loss of 1H is in no way affecting NavIC's performance.

The Indian hand in a French satellite

Vincent Lapeyrere's day at work starts with a 200 m walk from his office to the ground station at the Meudon Observatory outside Paris. He has a 10-minute window to issue commands to the PicSat satellite as it flies over Paris, which it does four times a day. Mr. Lapeyrere and his team are trying to reduce PicSat's spin by providing torque through on-board magnetorquers. PicSat is expected to become stable in two weeks, after which it will commence its mission of studying the star Beta Pictoris and try to detect the transit of its exoplanet Beta Pictoris b.

It took the PicSat team just three years to design and build the nano satellite, which is made of three cubes,



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

each just 10 cm in length, weighs no more than 3.5 kg and is equipped with a telescope which is 5 cm in diameter. The Indian Space Research Organisation (ISRO) played a pivotal role in the project's quick execution as its PSLV launcher successfully placed the satellite in the helio-synchronous orbit (about 500 km in altitude), on January 12.

Sylvestre Lacour, who is the principal investigator of the PicSat project, said they chose ISRO as they wanted the satellite in the orbit at the earliest. "ISRO has been very successful in deploying cubesats. Their schedule is fast and flexible, making it possible to get a slot at a short notice. And equally important, it is inexpensive," he said. Besides PicSat, PSLV's 42nd flight deployed 30 other satellites in space. Last February, ISRO managed to deploy a staggering 104 satellites in a single flight. They followed it up with a successful launch of 31 satellites in June. PicSat's mission is expected to last for a year, during which time it will be continuously monitoring Beta Pictoris, which is located about 63 light years from the Earth.

Transit phenomenon

Mr. Lapeyriere listed multiple reasons why this star was chosen. "It's a very young star, only 20 million years old. There is a debris disk around the star where the planet Beta Pictoris b was discovered a few years ago. It's a very young planet and is still in its formation phase. Studying this planet could improve our understanding of how planetary systems are formed," he said. PicSat will gather information about the planet by observing the transit phenomenon, when the planet passes in front of the star resulting in the change of its luminosity. By using this method, researchers can derive information about the size, density and composition of the planet. However, the transit window is quite small.

According to Mr. Lacour, it could happen any time. "The transit phenomenon occurs every 18 years. And viewing from earth, this phenomenon lasts for a few hours. We don't know the exact timing of this transit. It is for this reason that the star system has to be monitored continuously from space," Mr. Lacour said. Since PicSat flies over Paris for just half an hour every day, radio amateurs the world over have been encouraged to collaborate in the project. "Amateur astronomers with radio antennae can receive the satellite data and relay it to the PicSat database. The more data we collect, the better," system engineer Lester David explained.

In order to stabilise the satellite, an electrical current is run through the copper coils using on-board batteries and a solar array. "The current creates a magnetic field

around PicSat which is already inside Earth's magnetosphere. The magnetic field created by the coils align with Earth's magnetic field. That's how we are keeping PicSat stable," said Mr. David, who was at Sriharikota to witness the January 12 launch.

India records marginal increase in forest cover

India posted a marginal 0.21% rise in the area under forest between 2015 and 2017, according to the biennial India State of Forest Report (SFR) 2017. The document says that India has about 7,08,273 square kilometres of forest, which is 21.53% of the geographic area of the country (32,87,569 sq. km).

Getting India to have at least 33% of its area under forest has been a long standing goal of the government since 1988.

The 21% mark

However various editions of the SFR over the years, have reported the area under forests as hovering around 21%. So the government also includes substantial patches of trees outside areas designated as forests — such as plantations or greenlands — in its assessment. The total tree cover, according to this assessment, was 93,815 square kilometres or a 2% rise from the approximately 92,500 square kilometres estimated in 2015.

Andhra Pradesh, Karnataka and Kerala topped the States that posted an increase in forest cover. "Much of this increase can be attributed to plantation and conservation activities both within and outside the Recorded Forest areas as well as an improvement in interpretation of satellite data," the survey notes.

Currently, 15 States and union territories have 33% of their geographical area under forests. In India's north-east however, forest cover showed a decrease; 1,71,306 square kilometres, or 65.34%, of the geographical area was under forest and this was a 630 square kilometre decline from the 2015 assessment.

The category of 'very dense forest' — defined as a canopy cover over 70% — and an indicator of the quality of a forest, saw a dramatic rise from 85,904 square kilometres to 98,158 square kilometres this year but the category of 'moderately dense forest' (40%-70%) saw a 7,056 square kilometre decline from 2015.

"In different categories of forests there may be fluctuations within categories. However we are soon coming up with a comprehensive policy to address this," said Sidhanta Das, Director General of Forests.

Union Environment Minister Harsh Vardhan lauded the

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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

survey findings.

"India is ranked 10th in the world, with 24.4% of land area under forest and tree cover, even though it accounts for 2.4% of the world surface area and sustains the needs of 17% of human and 18% livestock population," he said at a press conference to release the survey results.

The forest survey for the first time mapped 633 districts and relied on satellite-mapping. Earlier this year, the government ceased to define bamboo as a tree to promote economic activity among tribals. The survey found that India's bamboo bearing area rose by 1.73 million hectares (2011) to 15.69 million hectares (2017).

Chandrayaan-II to be launched in April

India's second moon mission, Chandrayaan-II, which would land a rover on the lunar surface is expected to be launched in April, Minister of State, Atomic Energy and Space Dr. Jitendra Singh said.

"It is Chandrayaan-I which discovered water on the moon. This will be an extension of that," Dr. Singh said.

Chandrayaan-II would cost about Rs. 800 crore. It presented many technological challenges as it had three components: an orbiter, a lander and a moon rover.

Dr. Sivan of the Indian Space Research Organisation (ISRO) said the launch window was April to October and they would attempt to launch it in April.

The orbiter had a life of one year while the lander and the rover were designed to last a lunar day, which was 14 days, as they worked on solar power.

A location had been identified at the Moon's South Pole to drop the lander and rover.

"This site had not been explored by anyone before," Dr. Sivan added.

Boost to gravitational wave study

India's role in studying gravitational waves — touted as one of the most important discoveries of the recent past — will increase once the proposed gravitational wave observatory is set up in the country, said David Reitze, executive director of Laser Interferometer Gravitational-Wave Observatory (LIGO).

The observatory is expected to start functioning by 2025. "The more detectors we have and depending on where they are, the more accurately we are able to point in the direction in the sky. India having a detector improves that dramatically and that's going to be a big mission," said Mr. Reitze.

Gravitational waves are 'ripples' in the fabric of space-time, caused by some of the most violent and energetic processes in the universe such as merger of black holes or neutron stars. Its discovery saw three scientists get the

Nobel Prize for Physics in 2017.

Already, several physicists from Bengaluru-based International Centre for Theoretical Sciences (ICTS) are an active part of the LIGO project. In an interaction with The Hindu on the occasion of the 10th anniversary of ICTS, Mr. Reitze said after having announced the fourth successful detection of gravitational waves in September 2017, focus will now be on expanding their reach within the universe.

"We know we have binary black holes and binary neutron stars, so there must be a neutron star and black hole merger. We want to detect that. Our detectors are not very sensitive to supernovas because the amount of energy released by supernova in gravitational waves is very tiny, may be a billionth of what comes out of a black hole merger," Mr. Reitze said, hoping that they would be able to make a breakthrough in the coming years.

One way was to make the detector at least 40% more effective, allowing them to be more sensitive.

At present, the LIGO detectors are sensitive to about 70 to 80 megaparsec (280 million to 300 million light years) for binary neutron stars and for binary black holes, the sensitivity is about 2 gigaparsec (approximately 3 billion light years). With improved sensitivity, these detectors will be able to fetch information from farther distances in space.

ISRO mulls launching 65 satellites for a slew of uses

The Indian Space Research Organisation (ISRO) has set itself an ambitious to-do list of making and launching around 65 satellites for a slew of uses. They are planned to be realised over the period from 2017 to 2021, according to a top official.

This post-12th Five-Year Plan pace is stupendous as the number of satellites made in India over the last 40-odd years hit a century only a few days ago.

The last three, including two small ones, were rolled out of its Bengaluru centre in late December and are slated to be launched this month.

Jump in output

M. Annadurai, Director of ISRO Satellite Centre (ISAC), where spacecraft are assembled, told The Hindu that the new goal puts ISAC's annual asking rate at around 18 satellites a year: ISAC would now need to come out with three satellites every two months.

Since ISAC was set up in 1972 and until a few years ago, this used to be its average yearly output.

Dr. Annadurai said ISAC's 45-year tally peaked in 2017 with a record 12 spacecraft. "We rolled out Cartosat-

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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

2F, Microsat and INS-1C on December 20 [and shipped them out to Sriharikota for launch.] With these three satellites, we have made the maiden century of rolling out spacecraft from this centre,” he said in a New Year’s Day address to ISAC employees. “We can be counted in the league of Tendulkars and ViratKohlis,” he said.

ISAC’s spacecraft are meant for communication, navigation and Earth observation (EO), for both general and strategic purposes, while new emerging applications are getting added. In the four-year list, ISAC counts 26 for communication, 28 for EO and seven for navigation besides the scientific missions Aditya-L1 and XPoSAt, apart from a few small experimental satellites.

Awaiting approval

A few proposals that were made during 2017 are awaiting approval. A satellite launch costs Rs. 200-Rs. 300 crore depending on its size and the level of technology.

Dr. Annadurai said the centre was ready to rise to the challenge; its staff was routinely working almost 24/7. Last year, ISAC started to outsource some of the large and critical activities of satellite assembly and testing to Indian industry. The second such project for the ninth navigation satellite, IRNSS-11, is under way at an ISAC campus.

He said ISRO expected industry to give them the additional six satellites a year beyond the 12 that they would build.

PSLV all set to ferry 31 satellites tomorrow

The PSLV rocket, after a shocking falter four months ago, will return to the launch pad at Sriharikota.

A successful flight of PSLV-C40 is expected to put behind the Indian light lift rocket’s freak failure on August 31. During the forced hiatus, the Indian Space Research Organisation diagnosed why the nose cone of the previous C-39 rocket did not release the satellite; it took necessary corrective steps, officials said.

The launch is slated for 9.28 a.m. from the Satish Dhawan Space Centre in Andhra Pradesh. The countdown is set to begin Thursday morning.

Now among the world’s favourite and reliable commercial launchers for small satellites, the upcoming 42nd PSLV will carry a total of 31 satellites including 28 paid riders.

The main payload, the 710-kg Cartosat-2F, is the seventh in the Cartosat-2 series and is built to work for five years. Said to have a high, sub-metre resolution, it is unofficially said to serve military surveillance purposes.

Small satellites

ISRO is putting up two of its own small satellites — a 100 kg micro satellite and the 11-kg nano satellite INS-1C. There are also 28 smaller customers.

The commercial satellites include three 100-kg class micro satellites and 25 nanosats (1-10 kg) from Canada, Finland, France, Korea the U.K. and the U.S.

The PSLV has so far launched 209 small and medium satellites for foreign countries and earned revenue for the commercial arm, Antrix Corporation Ltd.

ISRO will be trying a two-orbit feat with the PSLV for the second time. , just after 17 minutes from take-off, the main satellite will be released first into a 505-km orbit, followed by 29 others.

Almost 1.5 hours later, microsat will be released into a lower 359 km orbit. Between the two orbits, the engine in the fourth stage of the rocket will be re-started twice during the course.

The flight lasting 2 hours and 21 minutes will be the longest of the PSLV, about six minutes longer than C-35 which was launched in September 2016.

Space companies bet big on PSLV

At least three overseas space companies have bet big on the PSLV-C40 launch of Friday. They each have put a 100-kg-class microsatellite on it as a testbed of their potential future constellations.

Also, at least two older constellation operators have brought new batches to be put in space by the Indian light-lifting launcher.

The PSLV, resuming after a failure in August, is placing these and 25 nanosatellites (up to 10 kg) in orbits 505 km away from Earth. The nanosats also carry experiments of companies and universities from multiple countries.

Rakesh Sasibhushan, CMD of Antrix Corporation, which markets the PSLV (and other ISRO services) to global satellite operators, said, “We have three important proof-of-concept microsats in C40. It is for the first time that such technology demonstrators have come together as customers on a single PSLV vehicle.” There had been one or two before but in singles.

New business

“Once the technologies are proven, they may lead to their operators’ firming up new constellations and the requirements for launching them in future. Hopefully they bring in more business to Antrix.”

Mixed luck

On its 42nd flight and 209 foreign customers behind it, the PSLV’s onus seems to be getting as big as the brand; a few of the current customers have tried other launchers



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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

but with mixed luck.

Antrix, the business arm of the Indian Space Research Organisation, earns Rs. 95 crore from arranging the PSLV-C40 flights for 28 customer payloads, which together weigh 503 kg.

ISRO workhorse PSLV-C40 puts 31 satellites in space

The Indian Space Research Organisation (ISRO) launched its 42nd Polar Satellite Launch Vehicle (PSLV) from the Satish Dhawan Space Centre in Sriharikota.

The PSLV-C40, which took off at 9.29 a.m, placed 31 satellites, originating from seven countries, in two orbits. ISRO termed the successful launch a New Year's gift to the nation.

The rocket was only briefly visible to onlookers on a foggy morning. Its primary payload was the fourth satellite in the advanced remote sensing Cartosat-2 series.

The Cartosat-2, whose imagery will be used to develop land and geographical information system applications, weighs 710 kg and was placed in a circular polar sun synchronous orbit 505 km from Earth. The satellite's design life is five years. The 30 co-passenger satellites together weigh 613 kg.

It was, however, the two other Indian satellites in the C40's payload that generated the most excitement. Called technology demonstrators, the microsatellite and the nanosatellite showed big strides towards miniaturisation.

The ISRO also used them to send a message to potential commercial customers, placing its microsatellite in an orbit different from the other 30. After deploying all the other satellites, the fourth stage of the rocket restarted twice to move from the 505 km orbit to a 359 km orbit to inject the microsat.

A.S. Kiran Kumar, for whom C40 was the last launch as ISRO Chairman, said the agency was utilising excess capacity to attempt a recovery of mission costs.

"We don't want to get into the specifics of money. We are not trying to build systems today for commercial launches. We are trying to build capacity for the demands of our own communication, navigation, observation," he said at a press conference.

Vikram Sarabhai Space Centre Director K. Sivan, chosen to succeed him was present.

The remote sensing microsatellite is of the 100 kg class with a mission life is 10 months. The nanosatellite, named Indian Nano Satellite-1C, is the third in its series. The INS-1C, whose mission life is six months, carries the Miniature Multispectral Technology Demonstration payload.

The ISRO Chairman said the Chandrayaan-2 was on schedule but did not commit to a March 2018 deadline.

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Vol. 13
News of Jan-Mar18

Atomic Energy

IACS' new source of white light

Now, pure white light can be produced using zinc, which is usually used to protect iron from rusting and in making brass.

The most commonly used method of producing white light is by mixing three primary colour-emitting phosphors in a proportionate composition. The existing methods of white-light production are energy-intensive and involve a long process.

But the new LED device requires only a single active layer of zinc-based metal-organic framework to get perfect white light under UV-excitation. And synthesis of the zinc framework is easy and highly stable and is not energy-intensive.

Scientists from Indian Association for the Cultivation of Science (IACS), Kolkata, synthesised the zinc-framework and the results were published in Journal of Materials Chemistry C.

“Zeolite, a rare earth mineral, is also used for producing white light. But this is not environment-friendly. Our LED device uses zinc, one of the most abundant metals on earth, to do the work,” explains Shyamal K Saha, Department of Materials Science at the Institute and corresponding author of the paper.

For the LED fabrication, indium tin oxide-coated glass was used as anode and vacuum evaporated aluminium as cathode. “The zinc-based framework is used as the active layer in which electrons are recombined to produce white light. The precursor materials used to make the LED are easily available and very much cost effective,” he adds. By checking with the International Commission on Illumination (CIE) standards, the researchers found that the emission was very close to that of ideal white light.

“The molecules were found to be very stable, and the

whole crystalline network was stable up to 500 degree Celsius” says Saptasree Bose, Research Associate and co-author of the paper.

While commercially available white LEDs show slightly higher blue emission when compared with two other primary colours, the new white LED emits three primary colours proportionally to get perfect white light.

“We calculated the energy levels and the origin of photoluminescence. Emissions were obtained at three different wavelengths (384nm, 468nm, 570nm) under UV-excitation,” says Tuhina Mondal, PhD scholar at the institute and first author of the paper. “The final LED requires 8V, which is a bit higher than commercially available LEDs. We are working to minimise this.”



TIFR team plays timekeeper to speeding electron bunches

Physicists at the Tata Institute of Fundamental Research (TIFR), Mumbai, have succeeded in studying electron bunches, kicked up to high speeds within a glass slab by a short duration laser pulse. They have measured the lifetime of these electron bunches within the material. And so long, this has been only guessed at. The work, published in The Physical Review Letters, lies at the forefront of high energy density science.

Only time in India

Such electron pulses, carrying mega-sized currents, are created by high intensity lasers in many labs. “We are not the first [to create such pulses]. But we are the only lab in India, and are among 10–20 labs in the world where people look at the basic physics of the transport of such mega ampere, femtosecond electron current pulses through high density (solid) media,” says Prof G. Ravindra Kumar of TIFR, Mumbai, one of the principal investigators of the experiment.



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

Such mega-sized current pulses cause secondary emissions from their targets, which can be x-rays, ions and the like, which have applications in medicine and imaging technology. Hence understanding their properties and interaction with the material they travel through is important.

“They [the secondary emissions] are also of a very short duration (picosecond or less) making them very useful for these applications. On a bigger scale, such megampere electron bunches are also expected to be used in laser fusion research and how they lose energy thereby heating the fusion target is extremely important,” says Professor Kumar.

Tabletop lasers

In the tabletop experiment done at TIFR in collaboration with P P Rajeev of Rutherford Appleton Labs, U.K., a high-intensity femtosecond laser pulse is aimed at a spot on a glass slab. Bunches of electrons from the glass slab are kicked up to high speeds close to that of light in vacuum. These continue to travel within the glass slab, but at speeds higher than that of light, because light slows down within the glass medium. Such ‘faster-than-light’ electrons emit a radiation known as Cherenkov radiation, which is what the researchers used to track them.

Using the ‘optical Kerr effect’, the researchers innovatively devise an optical ‘time gate’, which allows them to time the duration of the Cherenkov radiation. It is natural to expect that the electron bunch will stay together for a duration in the order of femtoseconds, which was the duration of the pulse that kicked them. However the electrons live approximately 2,000 times longer, for about 50 picoseconds.

“The Kerr gate time we generated was as short as 2 picosecond, allowing us to time the evolution of Cherenkov emission in the best possible manner ever. All earlier measurements had a time window [electronically generated, not optically as in this case] that was thousand times longer and could say nothing about the time evolution of the Cherenkov emission process,” says Professor Kumar.

The ability to create extreme states of matter using high power, femtosecond lasers gives a chance to create intrastellar and intraplanetary temperatures and pressures on a tabletop in the lab! You can ‘mimic’ those systems right on the earth, and that is the most exciting thing.

Supercapacitor built from discarded lithium ion batteries

Used old batteries can now help create supercapacitors, which can in turn create better long-lasting batteries.

Scientists from CSIR–Central Electrochemical Research Institute (CSIR-CECRI) in Karaikudi, Tamilnadu, and CSIR–Central Salt and Marine Chemicals Research Institute (CSIR-CSMCRI) in Bhavnagar, Gujarat, collected discarded lithium-ion batteries and created reduced graphene oxide from them. This new material showed high specific capacity at low current making it an ideal material for next generation high-performance supercapacitor.

“The specific capacity was found to be 112 farad per gram from fundamental evaluation, which is almost equal to the commercially available ones. Also the ones available in market today are created using activated carbon which is expensive and environmentally hazardous while our method is cheaper and fully environmental friendly” explains by Sivasankara Rao Ede, Ph.D scholar from CSIR-CECRI and one of the first authors of the paper published in *Colloids and Surfaces A: Physicochemical and Engineering Aspects*.

The new electrodes made using the reduced graphene oxide showed high stability even after 20,000 cycles. They also had high retention capacity where 70% of the efficiency was retained even after 85 cycles. The efficiency slowly increased and reached 108% after 20,000 cycles. The long-term stability and robustness of the capacitor are the key parameters for qualifying as suitable candidates for commercial application.

“Today lithium-ion batteries are used widely and



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

disposed after they run out, leading to mounting e-waste. We tried a new method and succeeded in recycling and reusing these batteries,” says DrSubrataKundu, from CSIR-CECRI and one of the corresponding authors.

The graphite anode and aluminium and stainless steel from dismantled batteries were used. The graphite was converted into graphene oxide by oxidation and subsequent exfoliation. Graphene oxide was further reduced to reduced graphene oxide.

Wind turbines

Supercapacitors are now being used explicitly in wind turbine pitch control, rail (on-board or way-side), automotive (including hybrid vehicles), heavy industrial equipment, UPS and Telecom systems for power delivery and memory backup. “We are further evaluating the capacitive nature of our prepared electrode in two electrode system and hope to bring it out soon for large scale commercial applications,” says H. C. Bajaj, emeritus scientist at CSIR-CSMCRI and the other corresponding author.

JNCASR's novel material to convert waste heat into electricity

A novel compound that exhibits poor thermal conductivity in the 25-425 degree C range but shows good electrical conductivity has been developed by a team of researchers led by DrKanishka Biswas from Bengaluru's Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR). The compound, silver copper telluride (AgCuTe), shows promise as a thermoelectric material for converting waste heat into electricity.

Since nearly 65% of utilized energy is wasted as heat, the focus is on developing materials that exhibit good thermoelectric property with both glass- and metal-like properties. Potential applications of the thermoelectric technology are in automobile industry, chemical, thermal and steel power plants where large quantities of heat are wasted.

Due to the low thermal conductivity of the material developed by JNCASR, one end of the 8 mm-long

rod that is contact with waste heat remains hot while the other end maintains cold temperature. The temperature difference is essential for the generation of electrical voltage. At the same time, the material exhibits good electrical conductivity like metal. The results were published in the journal *Angewandte Chemie*.

In the AgCuTe material, the silver atoms (cation) are weakly bound, giving rise to poor thermal conductivity due to the slow vibration of the lattice (soft lattice). At high temperatures, copper in the material further lowers the thermal conductivity along with silver. “Since the silver lattice vibrates slowly, it provides record low thermal conduction of 0.35 W per metre per kelvin, which is actually close to the glass,” Dr Biswas says.

“Both cations [silver and copper] contribute to low thermal conductivity but silver contributes more. Over 170 degree C, both silver and copper ions flow like liquid within the rigid tellurium sublattice, thereby reducing the thermal conductivity to the level of glass without affecting the hole (electrical carrier) transport,” says SubhajitRoychowdhury from JNCASR and first author of the paper.

Tellurium lattice

In contrast, the tellurium atoms (anion) are strongly bound and the lattice is very rigid. The strongly bound tellurium provides a conduction channel for holes thus rendering good electrical conductivity as seen in metals.

“By combining silver and copper with tellurium we have made our material as a combination of glass and metal — poor thermal conductivity and good electrical conductivity,” Dr Biswas says.

“Silver telluride does not have good thermoelectric property because it has higher thermal conductivity than our material,” says Roychowdhury.

It is a challenging task to have glassy and metallic properties in a single material, which is the fundamental challenge in the field of thermoelectrics. “We addressed this challenge through structural chemis-



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

try by creating a bonding hierarchy in the material,” Dr Biswas says.

The calculated efficiency to convert heat into electricity is 14% for the new material developed by JNCASR researchers. The lead telluride (PbTe) has higher efficiency of 18%. “But unlike lead telluride that contains lead, which is toxic, our material is lead-free,” he adds. The theoretical calculation to know the electronic structure was done in collaboration with Prof. Umesh V. Waghmare of JNCASR and coauthor of the paper. “We are trying to increase the efficiency by doping with different cations and anions,” Dr Biswas says.

Electricity from soil bacteria and reading lights from plants

We generate electric power through hydroelectric plants (in Bhakra, Nagarjunasagar or Hirakud dams), from coal and fossil fuels (Ramagundam, Bhilai and Neyveli), or nuclear plants (ones at Tarapur, Kudankulam or Kakrapar). Each method has its downside – be it water shortage or inter-state disputes, fouling the environment with pollution dust and greenhouse gases, or safety issues with radioactive damage. Can we at all have a pollution-free and nature-friendly power plant?

Biology appears to suggest a way. A group of researchers at the Wageningen University in the Netherlands, led by Dr. Marjolein Helder, has hit upon a method that generates electricity from living plants and the microbes that live beneath them in the soil, where the plants drop their roots. The plant of course does photosynthesis, using sunlight, water and atmospheric carbon dioxide, generating food in the form of carbohydrates and oxygen for our breathing. The microbes in the soil use some of this organic material coming out of the plants into the ground, metabolise them and, in the process, generate carbon dioxide and hydrogen ions and electrons.

While the plant above the ground does photochemistry, the bacteria beneath do electrochemistry, generating positive and negative ions. What Dr. Helder

and colleagues have done is to place positive and negative electrodes in appropriate positions and obtain an electric current, just as we do with batteries. This method of producing electricity is through what is termed as plant microbial fuel cells (PMFC).

Look at the simplicity of it. The method is completely natural and environment-friendly, needs no externally added material and is part of a cyclic process in nature. But how much electricity is produced with such PMFC? It depends on the size. A small 50 cm x 50 cm plot of a garden is estimated to produce 5 volts of electricity, while a 100 square metre garden gives enough electric power to charge a cell phone or to light up several LED light bulbs. Indeed the Wageningen group has lit up their Atlas building with LED bulbs, using PMFCs, and a mobile phone charging station in a place at the nearby town Tilburg.

Theory suggests that one should be able to generate 3.2 watts of electric power per square meter (3.2W/m²), using PMFCs. The best level obtained so far in practice is but a sixteenth of it, namely, 220 mW/m². Thus, improvement in efficiency needs to be done, both by adding such microbes in the soil which perform better, and by enhancing the area by miles and miles of grass lawns, farm lands and focus on paddy fields and similar acreages. These will also bring the cost-benefit ratio to acceptable proportions. It is with this in mind that Dr. Marjolein Helder came over to visit N. Chandrababu Naidu to consider taking up electricity generation across the state of Andhra Pradesh.

Plants that glow

Another dramatic advance, this one directly from the plants themselves rather than the microbes underneath, has come from Dr. Michael Strano of MIT, Cambridge, MA, USA. This is an audacious idea, namely, “how to make plants glow with light”! We know that a plant captures light, and using this, converts water molecules and atmospheric carbon dioxide into sugar. What Strano’s group aims to do is to make plants not just absorb but also emit light and, indeed, glow such that we may use such plants as a



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

table lamp to help read a book in a dark room! In other words, make a plant glow as a firefly does.

A firefly glows because it has an enzyme that converts a molecule called luciferin into oxyluciferin, and the energy released in this reaction comes out in the form of visible light. The enzyme is called luciferase. (Incidentally, luciferin is named after the Latin word lucifer, meaning light-bringer or the morning star). Now, plants do not have luciferin or luciferase. If we can somehow inject into a plant luciferin and luciferase, perhaps the plant too will emit light — this was the idea that Strano had. Towards this, he used the technology of nanoparticles.

Taking watercress and spinach as experimental plants, his group first packaged luciferase in nanoparticles made of silica. Then, they packed luciferin in another set of nanoparticles made of the polymer PLGA. Each of these nanoparticles carried a tag that would allow it to go to one specific part of the plant cells. Then they also devised a third nanoparticle system, packed with molecules called co-enzyme A, which was to remove a product of the luciferin reaction, which inhibits or stops the reaction from proceeding.

They now immersed the plant in water, added the three sets of nanoparticles, and applied high pressure so that these will enter and position themselves in appropriate places inside the plants. Now, the reaction proceeded and the plant emitted feeble glow, a Eureka moment, which lasted for about 3 hours!

Clearly, more tinkering needs to be done in order to brighten the glow, increasing the time it lasts and other issues. Also how to turn off the light when you do not need it anymore (this has already been established by adding a switch-up the off molecule at will). Given the progress, these appear doable soon enough. Strano says: “our work seriously opens up the doorway to street lamps that are nothing but treated trees and to indirect lighting around homes”.

Now, low viscosity fuel oil from plastic waste

Certain plastic wastes can soon help fuel your cars. Researchers from IIT Guwahati have successfully converted packaging plastic waste to plastic-derived oil (PDO), which has characteristics similar to diesel. Low- and high-density polyethylene (LDPE, HDPE) and polypropylene are commonly used as packaging materials and end up in the waste stream. According to a 2016 Central Pollution Control Board report, almost 15,000 tonnes of plastics waste is generated per day in India.

The researchers collected the waste (biscuit wrappers, shopping bags, food containers, shampoo bottles) from houses, cleaned and segregated them according to the resin identification code. These codes on plastics indicate the type of plastic resin it is made of.

Using a semi-batch reactor, the different wastes were heated for six to seven hours at 300-400 degree Celsius. “Heating at very high temperatures in inert conditions caused the plastic to convert into wax, so we chose this particular temperature range in which the plastic turned to plastic-derived oil and stayed in its oil state,” explains Pallab Das, PhD scholar at the institute and first author of the paper published in Resources, Conservation and Recycling.

But burning plastic waste generates pollution, particularly dioxins which are toxic to humans. “There is no oxygen in the three plastic wastes that is heated that we are also not supplying any oxygen. Pyrolysis is done under inert conditions. Only hydrocarbon gases such as methane, ethane and propane were produced and there was negligible amount of carbon dioxide and carbon monoxide produced,” says Das.

Further research

“More experiments need to be carried out to get a trade-off between the quality of the oil and the environmental pollution caused by the pyrolysis process. We are working on this and hope to create an ideal operating condition which can provide high-quality oil with less pollution,” says Dr. Pankaj Tiwari, Assistant Professor, IIT Guwahati, and corresponding



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

author of the paper. “Compared with combustion, pyrolysis causes less pollution.”

The researchers then studied the properties of the new plastic derived oil. One of the oil samples from polypropylene showed a high research octane number of approximately 92. Octane number indicates the quality of the gasoline range fuel. Premium petrol has research octane number of 98 to 100.

The oil also showed low viscosity and had high calorific value. Calorific value denotes the amount of heat generated when unit amount of sample was burnt with oxygen supply. The new oil had calorific value greater than 45 MJ per kilogram. Calorific value of petrol and diesel is 46-48 and 44-46 MJ per kilogram, respectively.

“We are yet to carry out engine tests. Once tested, these oils can soon find application in transport and industrial sectors,” says Dr. Tiwari.

Solar goal for 2022 too hot to handle

India had been on track to meet its target of 100 Gigawatt (GW) of solar energy capacity by 2022 but momentum has been severely eroded in the last few months, according to industry players. Issues such



as uncertainty around import duties and future tax rates on existing power purchase agreements have dampened investor sentiment.

“If you look at the trajectory India is on, [with] regard to solar capacity addition, real volumes have started to come and it’s accelerating too,” Andrew Hines, co-founder and head of business development (South India), Cleanmax Solar, told The Hindu. “If that tra-

jectory is to continue over the next few years, it will certainly be possible to get to that number.”

“A valid question is whether we are still on that trajectory or not, or whether we can expect volumes to grow at the same speed or not,” Mr. Hines added. “In the last 3-4 months, people’s confidence in that trajectory has weakened somewhat because of trade issues, to do with anti-dumping duties and safeguard duties”

The Director General (Safeguards) had earlier this year recommended imposing a 70% safeguard duty on imported solar cells, panels and modules for a minimum period of 200 days. No decision has been taken yet on this, but the proposal is causing a lot of uncertainty in the industry because of the higher costs this would result in.

“The 70% safeguard duty proposed will also inflate project costs by 25% and crank up the viable tariff to Rs. 3.75 per unit from Rs. 3 estimated earlier, making solar power less attractive to discoms,” Subodh Rai, senior director, Crisil Ratings, said in a release. “That would also be more than the average power purchase cost [for] 10 out of 14 discoms last fiscal.”

“It will obviously impose significant costs on developers,” Mr. Hines said. “Already the goal looks difficult and then you’re looking at imposing import duties on the primary materials of these projects, so of course that’s going to have an impact. The uncertainty around that is a concern for industry.”

‘GST is a dampener’

“[In the latest] Budget, we were hoping for a lot of things to happen, which did not take place,” Gyanesh Chaudhary, MD and CEO of Vikram Solar said. “In the pre-GST regime, we had zero tax on solar panels. Now it is 5%. There is a lot of confusion surrounding the GST on project execution. We need clarity on that. In a VUCA [volatility, uncertainty, complexity and ambiguity] environment, what do investors and financiers need? They need some sort of certainty.”

“With the advent of anti-dumping and the prospect of safeguard duties, and so many changes, it becomes



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

that much more uncertain.”

Ashish Khanna, CEO and ED, Tata Power Solar said, “While I agree that FY18 has been a good year as far as the installation of large-scale projects and the focus towards solar pumps are concerned, this recent phenomena of the last few months with regard to uncertainties of customs duty, and certain investigations taken by the government especially regarding the safeguard duty, I think, are not helping the environment.”

Last year, the global capacity addition in solar stood at 105 GW, according to Mr. Chaudhary, who added that India was in third place in terms of how much its market has grown over the year.

“What’s lacking is an effective ecosystem to make this happen in a speedy and time-bound manner,” Mr. Chaudhary said. “It’s riddled with a lot of complications and a lot of noise from the industry as well, where everybody wants protectionism. China has done nothing like that. It has created a bottom up approach where 60-70% of the global manufacturing in solar is from China.”

“They have built this huge ecosystem that is fuelling the growth,” he added. “Out of 105 GW last year, 52 GW came from China, so you can imagine the kind of installation that is happening there.”

The problem in India is that uncertainty surrounding tariffs coupled with a large target means that the road ahead to 2022 will be a tough one. Industry players across the board have said that they are waiting for more certainty before they bid for more projects or expand their existing projects.

“The installation base in solar in India has touched 20 GW,” Mr. Chaudhary said. “Our targets are 100 GW of solar by 2022. So, that gives us effectively four years. In the last 10-12 years, we have come from 10 MW to 20 GW. Now we have to do 20 GW every year to achieve the target, so it’s pure maths. Unless there is some serious might behind this, the target looks unlikely to be met.”

“We need to go into the details of what has happened,”

Mr. Khanna said. “In the case of bids, certain tariffs are decided upon but there was uncertainty over the incidence of future taxes and how they would affect the tariffs. Developers are not in a position to take a guess regarding the future statutory changes that are beyond their control.

“And, they cannot mitigate that risk by keeping a margin in the bid.” Another major issue that is causing industry players to slow their investments is the incidence of State governments trying to renegotiate past power purchase agreements due to lower tariffs being discovered subsequent to the signing of their PPAs.

Renegotiation by States

“The renegotiation of renewable power purchase agreement (PPA) tariffs by quoting high tariffs is not an apparent option available with State discoms,” India Ratings and Research said in a report. “Although there is no anecdotal evidence of cancellation of renewable PPAs in contravention to possible exit clauses available in PPAs, there have been instances of lower-than-contracted payments or grid curtailments. There is no direct evidence of PPA cancellation due to higher tariffs, except in Uttar Pradesh... However, additional clarity will attract investments in the sector.”

The report added that anecdotal experience shows high power cost (that States had signed off on) as the sole reason for the proposed renegotiation or cancellation of PPAs.

Solar power tariffs plunged to Rs. 2.44/kWh in May 2017 from Rs. 5.10 in June 2015. “It did hurt investor sentiment,” Mr. Chaudhary said. “There were a couple of cases where this was tried, but it didn’t fly with the courts. If something like that were to happen, it would crush the industry because there would be no surety.”

The other aspect that will likely hold up India’s achievement of the 100 GW target for solar is the rooftop solar component within this target. Out of the total, utility scale capacity is to make up 60% of

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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

the target and rooftop solar is to make up the remaining 40%.

“If the total achievement in solar is 20 GW today, then about 18 GW of that is probably from utility scale. On the rooftop side, I think the volumes installed today are modest. It’s less than 2 GW,” Mr. Hines said.

In other words, the utility scale segment has achieved 30% of the 2022 target with four years to go. The rooftop segment has achieved less than 4%.

What is International Solar Alliance?

What is this alliance?

The International Solar Alliance (ISA) was unveiled by Prime Minister Narendra Modi and then French President Francois Hollande at the U.N. Climate Change Conference in Paris on November 30, 2015. The idea was to form a coalition of solar resource-rich countries to collaborate on addressing the identified gaps in their energy requirements through a common approach. Towards this, the ISA has set a target of 1 TW of solar energy by 2030, which current French President Emmanuel Macron said would require \$1 trillion to achieve.

Who are the member countries?

The ISA is open to 121 prospective member countries, most of them located between the Tropics of Cancer and Capricorn as this is the region worldwide with a surplus of bright sunlight for most of the year. So far, however, only 56 countries have signed the ISA Framework Agreement. These include Australia, Bangladesh, Benin, Brazil, Burkina Faso, Cabo Verde, Cambodia, Chad, Chile, Comoros, Costa Rica, Cote d’Ivoire, Cuba, Djibouti, Dominican Republic, DR Congo, Equatorial Guinea, Ethiopia, Fiji, France, Gambia, Gabon, Ghana, Guinea, Guinea-Bissau, Guyana, India, Kiribati, Liberia, Madagascar, Malawi, Mali, Mauritius, Mozambique, Nauru, Niger, Nigeria, Peru, Rwanda, Sao Tome, Senegal, Seychelles, Somalia, South Sudan, Sri Lanka, Sudan, Suriname, Tanzania, Togo, Tonga, Tuvalu, UAE, Uganda, Vanuatu, Venezuela and Yemen.

What is India’s role?

Apart from being a founding-member, India plays a significant role in the alliance in terms of being a host as well as a major contributor to the achievement of the target. The ISA is the first international body that will have a secretariat in India. India, with a target to produce 100 GW of solar energy by 2022, would account for a tenth of ISA’s goal. “India will produce 175 GW electricity from renewable sources by 2022 and 100 GW will be from solar energy,” Mr. Modi said, addressing the ISA.

“Distribution of 28 crore LED bulbs in three years has saved \$2 billion and 4 GW of electricity. India will also provide 500 training slots for ISA member-countries and start a solar tech mission to lead R&D.”

Equipment for Kudankulam third reactor shipped from Russia

The first batch of equipment for Kudankulam Nuclear Power Project’s (KKNPP) third reactor, under construction, has been shipped from Russia.

PJSC ZiO-Podolsk, one of the enterprises of Rosatom Machine-Building Division ‘JSC Atomenergomash’, shipped out the first batch of equipment for the turbine hall and two high-pressure heaters last Tuesday, officials here said.

Four high pressure heaters each will be delivered for the third and the fourth 1,000 MW VVER reactors. The oversized equipment will be delivered at the KKNPP site using multimodal way. From the premises of Podolsk, the equipment were moved by railroad to St. Petersburg seaport. The cargo will reach Thoothukudi port and will be delivered at the KKNPP complex in April, said officials of Rosatom, Russia’s Atomic Energy Corporation.

Working design documentation had been elaborated by PJSC ZiO-Podolsk specialists. They would also implement the follow-up of the manufacture and subsequent site mounting supervision at the KKNPP site, officials added.

Rosatom’s JSC Atomenergomash is the supplier of key equipment for the KKNPP, which will house 6 x



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

1,000 MWe VVER nuclear reactors to be built with Russian assistance. For units 3 and 4, the company will manufacture steam generators, main circulation pumps, pressure compensators, pipe fittings, ancillary pumps, other equipment for reactor hall and turbine building.

Lithium ion batteries charge up rural houses

The shift towards lithium ion batteries from the older technology of lead acid batteries has allowed firms like Kaho India Private Limited to help the Centre achieve its rural electrification target even in areas beyond the reach of the grid.

Kaho India Private Limited, started in 2012, seeks to provide last-mile energy access through compact solar modules to areas that are so far not connected to the grid. "For instance, in Chhattisgarh, there are various tribal regions with no electricity and the grid cannot reach there maybe for the next 10 years because even roads cannot be built there due to the high intensity of LWE (left wing extremism) activities," Subhag Jain, CEO, Kaho India Private Limited, told The Hindu.

The device, developed by the company, can power three lights, one fan, one phone charger and has a socket to power a DC-power television. The firm provides all the related appliances as well, except for the TV.

The firm had initially developed a unit using lead acid battery but found that the short lifespan of these batteries rendered the entire product all but useless. "We imported 10 units for our first try in 2012, and they got sold in no time," said Mr. Jain said. "At that time, it was priced at Rs. 5,000. But everybody complained that these systems don't work.

"We were in a state of shock and excitement that a Rs. 5,000 product is selling like hot cakes in spite of the customer knowing that they don't work. Then, we stopped all commercial activity and got into an extensive R&D programme to understand why they don't work, and what we need to do to get them to

work reliably," he added. "It took two years to identify that the problem was with the battery." The problem, Mr. Jain explained, was that while the solar panel in the unit had a lifespan of 25 years, the lead acid batteries had a lifespan of only 2-3 years.

"And the battery is 40% of the cost of the product," he said. "These people don't want to spend 40% of the cost every 2-3 years to replace the battery and that's why the perception came that they don't work."

'Search for options'

Subsequently, the firm began looking at other battery options and settled on lithium ion batteries.

"This solved a lot of problems for the customer as well as for a lot of government schemes as well," he said. "In lead acid batteries, the typical calculation is that you have to put 8 VAh per peak watt of solar panel. In lithium ion, you need to do 4.8 VAh per peak watt. So, you have the size benefit. In a smaller package, we could put in more storage, so it also became cheaper for the government on a per-energy cost basis."

However, the introduction of the more efficient battery technology was accompanied by a rise in the price of the product. This, though, was not much of a problem for the firm because it decided to sell its products to the government instead of to individual households.

"Now, it priced at Rs. 50,000 per unit," Mr. Jain said. "But the government is buying them now under the REC plan and the Saubhagya scheme."

Another benefit of using lithium ion batteries was that they were much lighter than lead acid batteries, a key issue when delivering these units to remote locations. Also, the charging time had reduced by half with the introduction.

"Lead acid battery is said to be charged at what is called a c/10 rate, that is, it has to be charged for 10 hours," Mr. Jain said. "In lithium ion batteries, there are certain technologies where you can charge the battery in 10 minutes," he added.

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

ENVIRONMENT AND ECOLOGY

Elephants are irreplaceable seed dispersers

Wild animals play specific roles in the ecosystem, but what happens when they disappear? Using a combination of field data and theoretical modelling, scientists find that no herbivore can replace Indian elephants as the optimal seed dispersers of three large forest trees in West Bengal.

The dispersal of seeds far away from the parent tree maintains the high numbers of tree species in tropical forests. Trees depend on their fruit-eaters for seed dispersal, including elephants: the seeds of fruits they consume pass through their guts, come out undigested with dung and germinate when conditions are right.

But if elephants are lost from the ecosystem, can other herbivores take over this role? Scientists at Bengaluru's Indian Institute of Sciences and Princeton University, USA, quantified the role of Indian elephants and other herbivores (including Indian gaur, cattle, monkeys and wild squirrels) in dispersing the seeds of three tree species – the elephant apple tree (*Dilleniaindica*), the slow match tree (*Careyaarborea*) and chaplash, a jackfruit tree endemic to north-eastern India (*Artocarpuschaplasha*) – in Buxa Tiger Reserve, West Bengal.

The team collated previous field data, including camera-trapping and watching fruiting trees to see what fruits and how many each herbivore ate, counting seeds in dung and testing how many germinated. Using this and available data from literature, they quantified aspects of seed dispersal such as the time that seeds spent in animals' guts, the distance that the seed was dispersed and natural processes that killed dispersed seeds.

Incorporating these into a probability-based model, the team's study published in *Conservation Biology* found that without elephants, the number of seeds that survived after dispersal decreased to between 26% and 72% for each of the three tree species if other animals fail to compensate for the elephants. Though compensatory fruit removal by other animals negated this pattern, seed dispersal distance still declined by 30% for elephant apple and 90% for chaplash. Elephants dispersed seeds between 40 and 50 km, far higher than gaur (10 km) and cattle and buffaloes (5 km).

Elephant substitutes

"If elephants are not around to disperse these seeds, other herbivores – even in the most generous, optimistic scenario – cannot disperse as many seeds or disperse them as far," says author Nitin Sekar (Princeton University). "Losing elephants is equal to losing a fundamental part of the ecosystem here."

While studying more fruiting tree species would be crucial to draw more conclusions, it is important to look at ecosystem from these functional perspectives to conserve species, he adds.

CFC ban helped ozone hole heal, says study

An international ban on chlorine-containing man-made chemicals called chlorofluorocarbons (CFCs), has resulted in about 20% less ozone depletion, NASA said.

CFCs are long-lived chemical compounds that eventually rise into the stratosphere; where they are broken apart by the Sun's ultraviolet radiation, releasing chlorine atoms that go on to destroy ozone molecules.

Stratospheric ozone protects life on the planet by absorbing potentially harmful ultraviolet radiation that can cause skin cancer and cataracts, suppress immune systems and damage plant life.

By comparing the Microwave Limb Sounder (MLS) measurements of hydrochloric acid and nitrous oxide each year, the scientists determined that the total chlorine levels were declining on average by about 0.8% annually. The study was published in the journal *Geophysical Research Letters*.

To determine how ozone and other chemicals have changed year to year, scientists used data from the MLS aboard the Aura satellite, which has been making measurements continuously around the globe since mid-2004. The change in ozone levels above Antarctica from the beginning to the end of southern winter — early July to mid-September — was computed daily from MLS measurements every year from 2005 to 2016.

When ozone destruction happens, chlorine is found in many molecular forms. But after chlorine has destroyed nearly all the available ozone, it reacts instead with methane to form hydrochloric acid, a gas measured by MLS. According to the study, the Antarctic ozone hole should continue to recover gradually as CFCs leave the atmosphere, but complete recovery will take decades.

Deep-rooted trees more likely to die in drought

Droughts can kill, but you would imagine that deep-rooted



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

forest trees – whose roots tap into more permanent water resources – would be the least affected. But a study now finds that droughts killed tree species that access deeper water much more.

Tree deaths due to droughts are a major threat in both temperate and tropical ecosystems. This could further aggravate with climate change, with droughts predicted to increase in many parts of the world.

In a deciduous forest, where water is scarce especially in summers, how do different tree species with varying root depths deal with such water stresses? An inter-disciplinary team from institutes including Bengaluru's Indian Institute of Science (IISc) studied how different species partition underground water resources up to a depth of 30 metres (just above the groundwater table) in Tamil Nadu's Mudumalai National Park. In a 50-hectare forest plot, the scientists measured how much 7,677 trees belonging to 12 common tree species grew and how many others died between 1992 and 2012, which also saw an intense drought (2000 to 2003). The team collected local hydrological data including daily rainfall and water-holding capacities of local soils to estimate how much water is available across varying soil depths. Devising a novel eco-hydrological model to quantify the depths from which trees took up water, the scientists find that while species like teak that absorbed water from near the surface may be adapted to droughts by surviving on scanty rainfall across the year, others like axlewood (*Anogeissus*) and laurel (*Terminalia*) took water from the deeper depths composed of weathered rocks. Their study, published in the *Journal of Ecology*, shows that though species that access deep water experience fewer droughts, they are more vulnerable to protracted droughts.

Water uptake

"The deepest water compartments that dried up during the drought took longer to recharge," says lead author Rutuja Chitra-Tarak, then doctoral researcher at IISc. "We found that co-existing tree species diverged in water uptake depths, species using deep-water experienced drought more intensely, and thus died more – the first study to demonstrate this."

Climate change—droughts could kill such species, says Chitra-Tarak. "At large scales, this can even lead to lesser water being recycled into the atmosphere, worsening droughts," she says.

This novel hydrological modelling approach can help scientists model the impacts of increasing droughts on forests and their feedbacks on climate change. Chitra-Tarak is currently testing this across forest types and climates

across the world.

Tourists alter python sun-basking patterns

It is something they really need to do, but these rock pythons aren't soaking up the sun like they should. Scientists find that tourists in Rajasthan are venturing close to these cold-blooded reptiles and altering their sun-basking behaviour by forcing them to retreat to their burrows often. This could affect their physiology and lower breeding rates in a region home to the highest number of rock pythons in India.

Snakes and other cold-blooded animals have to regulate their body temperatures behaviorally, by living in burrows or basking in the Sun. To study how Indian rock pythons adapt to extreme weather conditions in Keoladeo National Park (where temperatures range between 0.5 and 50 degrees Celsius), scientists at the Salim Ali Centre for Ornithology and Natural History (SACON) and Manipal University (MU) monitored up to 47 burrows for three years (2013-2016). Each burrow housed up to three pythons; in their paper published in *Global Ecology and Conservation*, the team estimates the python population in the 29-sq-km Park to be around 80.

Camera traps

To monitor the snakes' basking patterns, the scientists installed camera traps at six burrows from October 2015 to May 2016. The pythons were most active during February; they usually emerged out of their burrows between 9 and 10 a.m. and retreated between 5 and 6 p.m, basking continuously for 4-5 hours a day with their mean basking time peaking at noon.

To check if the Park's high tourist inflow affects the pythons' basking patterns, the team also installed one camera trap each near a disturbed, semi-disturbed and undisturbed burrow (classified based on tourist footfall). With the cameras deployed across 182 days, the team finds that pythons in undisturbed burrows basked for an average of 60 minutes per day. In disturbed burrows, however, pythons retreated just after noon and spent only around 36 minutes basking.

Tourists repeatedly approached specific burrows to less than 10 metres, forcing pythons to retreat and emerge more frequently. "This could prevent them from maintaining an optimum body temperature, leading to production of infertile eggs and thus lowering breeding rates," says author H. N. Kumara, senior scientist (SACON).

In response, the Rajasthan Forest Department is taking lead author Aditi Mukherjee's help to revise the Park's



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

management plan. "We are now permitting tourist access to only two spots and from a safe distance," says Chief Wildlife Warden G. V. Reddy.

Want to save the planet? Try using less deodorant

The deodorants, perfumes and soaps that keep us smelling good are fouling the air with a harmful type of pollution — at levels as high as emissions from today's cars and trucks.

That's the surprising finding of a study published last week in the journal *Science*. Researchers found that petroleum-based chemicals used in perfumes, paints and other consumer products can, taken together, emit as much air pollution in the form of volatile organic compounds, or VOCs, as motor vehicles do.

The VOCs interact with other particles in the air to create the building blocks of smog, namely ozone, which can trigger asthma and permanently scar the lungs, and another type of pollution known as PM2.5, fine particles that are linked to heart attacks, strokes and lung cancer.

Smog is generally associated with cars, but since the 1970s regulators have pushed automakers to invest in technologies that have substantially reduced VOC emissions from automobiles. So the rising share of air pollution caused by things like pesticides and hair products is partly an effect of cars getting cleaner. But that breathing room has helped scientists see the invisible pollutants that arise from a spray of deodorant or a dollop of body lotion. The researchers said their study was inspired by earlier measurements of VOCs in Los Angeles that showed concentrations of petroleum-based compounds at levels higher than could be predicted from fossil-fuel sources alone. Concentrations of ethanol, for example, were some five times higher than expected. And those levels were increasing over time.

"You can see these really rapid decreases in tailpipe emissions," said Brian C. McDonald, a scientist at the Cooperative Institute for Research in Environmental Science at the University of Colorado, Boulder, who led the study. "It just made sense to start looking at other sources and seeing whether they could be growing in relative importance."

Even though drivers can use gallons of gasoline each week, "It's stored in an airtight tank, it's burned for energy, and converted mostly to carbon dioxide," said Jessica B. Gilman, a research chemist at the National Oceanic and Atmospheric Administration also involved in the study. Those carbon dioxide emissions are not smog-forming

VOCs, though they are a major driver of human-caused climate change.

"But these VOCs that you use in everyday products — even though it may just be a teaspoon or a squirt or a spray — the majority of those kinds of compounds will ultimately end up in the atmosphere, where they can react and contribute to both harmful ozone formation and small-particle formation," Gilman said.

Forty per cent of the chemicals added to consumer products wind up in the air, the researchers found.

To make their calculations, the study's authors constructed a computer model that simulated air quality in Los Angeles, weaving in data from the chemical composition of consumer goods and tailpipe emissions. Using the model, they could see the fingerprints of the chemical compounds coming from personal care products and also estimate how many VOCs from paints and finishes inside buildings were being released to the outside world. Roughly half of the VOCs in Los Angeles air could be attributed to consumer products, the authors found.

Concerned consumers may be tempted to turn to "natural" products, though the researchers say that isn't a cure-all. For example, one class of compounds called terpenes gives many cleaning products a pine or citrus smell. These terpenes can be produced synthetically or naturally from oranges.

"But whether it's synthetic or natural, once it gets into the atmosphere it's incredibly reactive," Gilman said.

Galina Churkina, a research fellow at the Yale School of Forestry and Environmental Studies who was not involved in the study, noted that the study did not consider emissions related to biological sources like trees and animals. But the authors said their study was not the end of this line of research.

There are tens of thousands of chemicals in consumer products, and researchers have not yet pinpointed which chemicals are most likely to form ozone or PM2.5 particles. "One of the things that we're hoping the public takes away from this is that our energy sources and the consumer products we use every day are continually changing the composition of our atmosphere," Gilman said.

Notably, some of the VOCs used in consumer products were replacements for chlorofluorocarbons, or CFCs. Those chemicals were phased out beginning in the 1980s because they thinned the Earth's ozone layer. For consumers looking for a greener solution, McDonald offered some advice. "Use as little of the product as you can to get the job done," he said. *NY Times*



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

Ancient climatic changes and central India's rare forest owl

Between four and six million years ago, long before human's evolved, drastic climatic changes in the Indian subcontinent led to the evolution of a new bird: central India's now-endangered and rare forest owl. Scientists have also found that it belongs to the same genus as the commonly-seen spotted owl, finally settling a century-old debate on its genetic relationship with other Indian owlets.

The taxonomy of the forest owl (*Heteroglauxblewetti*), which resembles the spotted owl *Athene brama*, has always been a mystery. Taxonomists placed it in a separate genus *Heteroglaux* and sometimes in *Athene*; others saw it as more closely related to another species, the jungle owl.

For the first time, a team of scientists obtained permits to carefully take some feathers from forest, spotted and jungle owlets in the states of Madhya Pradesh, Maharashtra, Gujarat and Chhattisgarh. From the feathers, they extracted DNA (of five genes, both mitochondrial and nuclear) and built a genetic tree to reveal the relationship between the birds. Their results show that the forest owl belongs to the same genus (*Athene*) as the spotted owl, thus settling a century-old debate about its taxonomy. According to their paper published in PLoS ONE, the bird can now be known as *Athene blewetti*.

Fossil records

Using dated fossil records of ancient owls on this genetic tree, the team estimated the time at which the forest owl diverged from its nearest relatives, the process by which new species evolve. Their results show that the forest and spotted owlets split as different species between 4.3 and 5.7 million years ago, when drastic climatic changes occurred in the Indian subcontinent.

"Multiple cycles of wet and dry climates characterized the Indian subcontinent then," says lead author Pankaj Koparde (Salim Ali Centre for Ornithology and Natural History). "Independent research shows that this period, the Plio-Pleistocene, also saw the speciation of several other high-altitude birds in the Western Ghats."

This means that climate played a major role in the speciation of the owlets, says Koparde. With climate change being a concern now, it would be important to study how new weather events affect the forest owl, he adds.

This would be crucial to conserve the species, which is rare and found in a severely fragmented habitat threatened by the activities of humans, a species that came into being a few million years after they did.

Physics theory explains patterns of deforestation in the tropics

Predicting rising numbers is usually good news in ecology, but not if they refer to forest fragments. Current rates of deforestation could cause a 33-fold increase in forest fragments over the next 50 years, shows a study published in *Nature*. Deforestation, fuelled by factors including habitat conversion and timber production, causes fragmentation. As large forests are cut into pieces, biodiversity suffers and carbon is also lost. To study patterns of tropical forest fragmentation, scientists at the Helmholtz Centre for Environmental Research (Germany) used remotely-sensed images to map more than 130 million forest fragments across 427 million hectares in the Americas, Asia, Africa and Australia.

Across continents

They found that fragment sizes in three continents followed similar frequency distributions. The number of forest fragments smaller than 10,000 hectares, for instance, is similar in Central and South America (11.2%), Africa (9.9%) and Southeast Asia (9.2%).

"This is surprising because land use noticeably differs from continent to continent," said mathematician and lead author Franziska Taubert in a press release. While habitat conversion is what plagues the Amazon, it is logging of commercially-important forest trees in Southeast Asia.

So how was local deforestation causing similar fragmentation patterns on a global scale? The scientists found the explanation in percolation theory, which explains how individual particles of an object cluster, transforming the object itself once it reaches a critical point. The theory (which has been used to explain phenomena including the trickling of water through soil and patterns of forest fires) states that in a certain phase of deforestation, the forest landscape exhibits structures that can be found repeatedly. The scientists found that forest fragmentation is currently close to a critical point beyond which fragment number will strongly increase.

Using this to predict future patterns of forest fragmentation, the team found that any additional forest loss can decrease fragment size and cause a 33-fold increase in the number of forest fragments over 50 years.

Repercussions

Though their models show that this could be partly mitigated by reforestation and forest protection, there will be repercussions for countries that fall in these zones, including India. More fragments mean more edges which

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

are highly disturbance-prone and decrease habitat quality for wildlife.

“Carbon stocks tend to reduce in fragments due to several reasons including loss of large trees and edge effects which often favour tree species with lower wood densities,” said scientist JayashreeRatnam of Bengaluru’s National Centre for Biological Sciences.

New plant species from West Bengal

Scientists from the Botanical Survey of India have identified a new plant species from two protected National Parks in West Bengal. Named *Drypetes kalamii*, it is a small shrub found to be shorter version of its close relative *Drypetes sellisii*. This adds to the rich floral wealth of India.

Standing just 1 metre tall, the newly described plant is unisexual in nature, which means they have separate male and female plants.

“During the survey and documentation of the flora of Buxa National Park, West Bengal (core area of Buxa Tiger Reserve), in 2011, I came across these plants, but could not identify them. Another author of the paper had collected a new female plant with fruits from Jaldapara National Park, West Bengal. The fruiting specimen can be easily identified in *Drypetes*. We later found that both the plants belonged to the same species. Further consultations with plant biologists from India and abroad helped us confirm its new identity,” says Dr Gopal Krishna from BSI who is the first author of the paper published in *Phytotaxa*. The researchers compared the new plant with other *Drypetes* species and found differences in the leaf, flower and fruit structures. There are about 220 species of *Drypetes* identified across the globe of which 20 have been reported from India.

Medicinal cousin

“The new species is a close relative of a medicinal plant known in Sanskrit as *Putrajivah*”, says Dr K. Karthigeyan, scientist at BSI and corresponding author of the work. “NASA had recently named a new bacterium after Dr Kalam, and we also chose his name as he is a big inspiration for students and young researchers,” adds Dr Karthigeyan.

The new species is found in wet, shaded areas of subtropical moist semi-evergreen forests, at a height ranging 50-100 metres. With pale yellow flowers in clusters and bright orange to red fruits, the plant is exclusive to the two national parks.

By following the IUCN (International Union for Conservation of Nature) rules, the scientists have provisionally as-

sessed the plant to be “Critically Endangered”. The report states forest fires and grazing as two plausible threats to the new species.

NASA observes dramatic rise in sea levels

The sea level may rise twice as high by 2100 as previously estimated because of climate change, a NASA study says. According to findings detailed in the journal-*Proceedings of the National Academy of Sciences*, rise in sea level may increase by up to 65 centimetres in the next 80 years, which will do to cause significant problems for coastal cities, *Space.com* reported on Friday.

This is believed to be a conservative estimate by scientists.

Coral sediments in oceans could dissolve by next century

As oceans get more acidic, sediments that constitute coral reefs could begin dissolving by the end of this century, suggests a study published in the journal *Science*.

Coral reefs are formed by not just the calcium carbonate skeletons that tiny animals called coral ‘polyps’ create, but also carbonate sediments which accumulate on them over thousands of years. Ocean acidification – lowering of sea water’s pH when it absorbs the excess, human-caused carbon dioxide from the atmosphere – prevents polyps from building their stony skeletons.

In several reef systems, acidification also dissolves corals’ carbonate sediments. Scientists from several institutes including the Southern Cross University in Australia studied this less-explored aspect of sediment dissolution at 57 locations across five reefs in the Pacific and Atlantic Oceans. They found that the link between sediment dissolution and acidification is stronger than that between acidification and coral formation.

Predictions

Based on this, the team also predicted changes in coral systems by incorporating several factors including current rates of coral formation and sediment dissolution. According to their calculations, coral sediments will begin dissolving by 2050; by 2080, they will dissolve faster than they are formed.

“It would be extremely worrying if this does start to happen,” says scientist Rohan Arthur of Nature Conservation Foundation, who studies the coral reef systems of India’s Lakshadweep Islands. “This could add to the problem of coral decline that we are already seeing because many of the reefs in the Indian Ocean are already net eroding.”

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

This means ocean acidification is causing coral reef systems to erode rather than grow. Currently, the processes of coral formation are also under threat. In 1998, Lakshadweep's reefs experienced bleaching: increased ocean temperatures caused algae that live as symbionts within corals to leave, stressing the corals. Two more bleaching events followed in 2010 and 2016. With repeated bleaching, frequent storms due to climate change and now, ocean acidification that causes sediment dissolution apart from slowing down coral-building, Lakshadweep's reefs could be facing a triple whammy, says Arthur. "Local factors like over-fishing in reefs too play a role," he adds.

Indian reefs

Coral reefs span 3,062 sq. km in India. Many coral species are afforded protection at par with tigers: they are included in Schedule I of the Wildlife Protection Act (1972). While coral systems support a diversity of fish species that local communities depend on for sustenance, many like those in Lakshadweep also provide protection from storms and prevent coastal erosion.

Maharashtra's two potentially endangered endemic shrubs

Crotalaria species (ripe fruits of which are used by children as rattles) are small shrubs bearing bright yellow blooms and are common across the Indian countryside. But Indian botanists have just discovered two rattlepod species — woody and multi-bracted rattlepods — that survive only in the hill tracts of Maharashtra.

Of the 85 species of rattlepods or Crotalaria found in India, 73 survive only in peninsular states. Many of these are concentrated along the Western Ghats and it takes a trained eye to discern the (often) slight physical differences between various rattlepod species. On their field trips to Maharashtra's Kolhapur district in 2011 and 2015, researchers at the University of Delhi's Department of Botany spotted two types of rattlepods that looked unlike any they had seen before. Intrigued, they collected specimens and measured in detail the fine morphological features specific to these plants in their lab. They found that the width of the keel (one of the petals of a flower) was different from any of the other rattlepod species seen in the area. "The degree to which the keel is twisted in the flowers also emerged as an important characteristic," says Arun Pandey, professor at the University of Delhi, who led the study published in PLOS ONE recently.

Two species

To make sure they were looking at two different species, the botanists also analyzed the plants' DNA and studied

portions of two plant genes. Using six samples of the new plants, they built a genetic 'species tree', which shows the plants' genetic affinities with other rattlepod species. This reveals that both the new shrubs are different enough to warrant recognition as separate species.

The team named one species *Crotalaria suffruticosa* ('suffruticose' means woody at its base, but herb-like above). This 'woody' rattlepod is found in grasslands and forest edges in two localities in Kolhapur's KarulGhat. The second, *Crotalaria multibracteata* (named after its several bracts – small modified leaves at the bases of flowers) or the 'multi-bracted' rattlepod survives on rocky and dry surfaces in just one locality in the nearby Panhala region. This limited geographical distribution necessitates that both plants be classified as 'endangered' as per the criteria set by the IUCN, write the authors.

"Anthropogenic activities such as clearing and burning of forests and grasslands in the non-protected areas where we found them could threaten their existence," says Prof. Pandey, adding that conserving these habitats is crucial for the rare shrubs.

Do Olive Ridley turtles reach the Odisha coast using magnetic power?

One of the magnificent sights to behold in India is the arrival and nesting of tens of thousands of Olive Ridley turtles on the Gahirmatha seashore of Odisha every year as clockwork. They traverse thousands of kilometres northwards on the Indian Ocean south of Sri Lanka, land, nest and produce baby turtles, and after a while, return. The temperature, the season, the natural environmental resources all fit perfectly for this grand continuity of life.

Built in GPS

What kind of global positioning system (GPS) do these turtles have, allowing them to do this year after year? The details of the answer are yet to be worked out. There are two major theories that attempt to address this issue. They both use the fact that Mother earth is a huge magnet, with well-defined North and South poles, a magnetic axis and with an intensity or strength that varies systematically across the surface. Turtles appear to use this cue to move and position themselves for this vast journey. Towards this, it is claimed that each turtle itself is a tiny magnet.

Turtles are but one example. Other marine animals such as a variety of fish and lobsters, birds, bees, bats and even mammals such as dogs and some primates seem to have such a built-in compass. (Apparently dogs position themselves north to south as they urinate or defecate!). It appears that all but humans have such a compass, or

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

what is technically described as geo-magneto-reception. What then are the two theories? One, suggested by two veterans in the field, Joseph Kirschvink of Caltech and Kenneth Lohmann of the University of North Carolina, argues that these animals have tiny magnets in their bodies. This magnet arises due to the presence of a material called magnetite (an iron-based mineral containing Fe_3O_4). These two groups have been systematically looking for magnetites in fish (such as the zebrafish - the favourite of experimental biologists), turtles, birds and so forth. (See, for example, the review "Geomagnetic imprinting: a unifying hypothesis of long-distance natal homing in salmon and sea turtles" by KJ Lohmann, NF Putman and MF Lohmann, PNAS (US) 105: 19096, 2008, and "Birds, bees and magnetism: a new look at the problem of magnetoreception" by J. Kirschvink, in Trends in Neurosciences, 5: 160, 1982).

Biochemical approach

At about the same time, the group led by Prof. Klaus Schulten of the University of Illinois, has been pursuing and pushing a more biochemical approach to magnetoreception. They suggest that the key molecule here is a protein called cryptochrome, which is found in the retina of the eye.

This protein has a long evolutionary history, found not only in plants, but also in fish, turtles, amphibians, birds and animals (humans too). Schulten points out that when blue light falls on this proteins, a pair of free radicals are generated, which do not quench each other (as free radicals normally do) but form an 'entangled pair', which generates a tiny magnetic piece. And it is this tiny molecular compass that aligns and interact with the earth's magnetic field, leading to the movement of the animal (see "Cryptochrome and magnetic sensing- animal magnetoreception", in <ks.uiuc.edu>).

Which of the two is right, or do they work in tandem? Some answer to this has come from a recent paper by the group of Dr. Gil G. Westmeyer of the Technical University of Munich, Germany, which has appeared in Nature Communications last month (Nature Communications | (2018) 9:802). Using zebrafish and another fish called medaka, they shone blue light on the fish and found that they responded as predicted by Schulten. However, even when they shone not blue or visible radiation at all, but infrared, wavelengths, the fish still responded the same way. This suggested that there are alternate or additional mechanisms available (suggesting that Kirschvink too may have a point). Clearly more work needs to be done, using not zebrafish and medaka alone, but birds, and ani-

mals too.

Given that Olive Ridley turtles are available, and a good summary about them is available from the Wild Life Institute of India, and even some aspects of their DNA have been studied, it will be well worth some researchers from India to study their magnetoreception behaviour both by examining their magnetite content on one hand and cryptochrome activities on the other. This would add to our understanding of the basis of their magnetoreception, a field that waits to be investigated at greater depth.

There is still this question of whether we humans are magneto receptive, too. Do we have magnetite in our bodies? While some have claimed that we do, others have questioned whether they came to us through biological inheritance (biogenic) or we have accumulated it thanks to atmospheric pollution (which is rich not only in oxides of carbon, nitrogen, sulphur and oxygen itself, but also from soot, flyash and other sources which contain iron in them; or 'anthropogenic'. Studying human populations from tribes and areas where such pollution levels are nil, or at least the lowest would be useful. On the other hand, we do have two versions of cryptochrome in our body (Cry1 and Cry2). Their photo-magnetic properties will also be of interest. Here is another research theme that should be pursued.

Damaged reefs turn butterflyfish into flexible eaters

Fewer options on the menu could force you to be a less fussy eater. At least that's what Lakshadweep's melon butterflyfish experience, find scientists. In bleached coral reefs that host less food resources, these fish change their diets and eating patterns to adapt to reef damages caused by climate change.

Climate change-induced ocean warming can cause coral bleaching, which stresses coral patches and makes them prone to death. Bleaching is not new in Indian reef systems; the bleaching event of 2010 killed patches of corals in several reefs off the Lakshadweep Islands. This can be catastrophic for exclusive coral-eaters like melon butterflyfish. How do they deal with this?

Live coral cover

Scientists from Bengaluru's Nature Conservation Foundation (NCF) and National Centre for Biological Sciences (NCBS) studied live coral cover and butterflyfish numbers in three reefs fringing the islands of Kadmat (coral death was highest here with only about 7% live coral cover and, therefore, resource-poor), Bitra and Kavaratti (least coral death, nearly four times more live coral cover than Kad-



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

mat) in Lakshadweep. Surprisingly, their surveys show that despite these large differences in coral cover across the reefs, melon butterflyfish numbers were similar in all three.

Fish behaviour caught on the team's underwater videos showed why. The video footage recorded the coral species that 58 pairs of melon butterflyfish they followed ate, the time the fish spent eating and the time they took to travel between patches of live coral to obtain food. In resource-poor reefs, fish ate coral species that they otherwise clearly avoided in rich reefs like Kavaratti. Fish spent more time travelling and less time searching for food in resource-poor reefs, making food procurement both difficult and energetically expensive. To compensate for this, the fish ate more 'compulsively' in such reefs, taking faster bites (about two times quicker than in rich reefs) off corals in a hurry, write the scientists in their study published in the journal *Ethology*.

This flexibility in butterflyfish is something that his team has documented in other reef fish such as predatory groupers too, wrote co-author of the study Rohan Arthur of NCF in an email to *The Hindu*. "What is emerging from reefs like the Lakshadweep is that the ability to be flexible is going to be a key ingredient that separates the 'winners' from the 'losers' as reefs decline," he wrote. However, such short-term resilience may not guarantee longer-term survival, according to the scientists.

India's endangered Asiatic lion population increases to 600

The endangered Asiatic lion, which only lives in one forest in India, has fought back from the verge of extinction, with its population increasing to more than 600, a minister said, hailing a major conservation campaign.

The lion, which once roamed across southwest Asia but is now restricted to the 1,400 square kilometre (545 square mile) Gir sanctuary in Gujarat state, was listed as critically endangered in 2000, with its population under threat due to hunting and human encroachment on its habitat.

A recent unofficial count found more than 600 lions in the area, up from 523 in a 2015 census, Gujarat's chief minister Vijay Rupani said.

"Our efforts for lion conservation with support of local people have yielded good results. The number of lions now in Gujarat has reached the 600 mark," Rupani said. In the late 1960s only about 180 Asiatic lions were thought to survive but an improvement in numbers prompted conservationists to raise their assessment to endanger in 2008.

The population is currently growing at about two percent a year, according to A.P. Singh, a state forest and wildlife conservationist.

The cats are cousins of the African lion — they are believed to have split away 100,000 years ago — but are slightly smaller and have a distinctive fold of skin along their bellies.

They are a major tourist attraction in Gujarat where in the past they were the target of poachers.

Priyavrat Gadhvi, a member of Gujarat's wildlife board, credited conservation schemes, well-trained staff and vets as well as help from farmers for the recovery in numbers.

"There is tremendous support from the local population in Gujarat who are tolerant despite lions attacking their cattle. This is coupled with effective conservation management and skilled staff at ground level," he told AFP.

Gadhvi predicted a "steady growth" in numbers in coming years. The next official census will be in 2020.

Conservationists have suggested relocating some of the cats to another sanctuary, to reduce human-animal conflict and avoid the risk of the Asiatic lion being wiped out by disease or a natural disaster.

Scientists may be closer to finding a way to turn CO2 into usable energy

Can carbon dioxide (CO₂)—a greenhouse gas whose high emissions contribute to global warming—be turned into usable energy? Scientists believe this can be done. They are now one step closer to making it a reality, and claim to have identified a "new electrocatalyst that efficiently converts CO₂ to carbon monoxide (CO), a highly energetic molecule".

The study by a team of researchers including scientists at the US department of energy's (DOE) Brookhaven National Laboratory was published in February in international journal *Energy & Environmental Science*.

"There are many ways to use CO ... You can react it with water to produce energy-rich hydrogen gas, or with hydrogen to produce useful chemicals, such as hydrocarbons or alcohols. If there were a sustainable, cost-efficient route to transform CO₂ to CO, it would benefit society greatly," Eli Stavitski, a scientist at Brookhaven and an author on the paper, said in a statement.

The findings are significant as "scientists from long have sought a way to convert CO₂ to CO but traditional electrocatalysts cannot effectively initiate the reaction. That's because a competing reaction, called the hydrogen evolution reaction (HER) or water splitting takes precedence



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

over the CO₂ conversion reaction,” the study explained. “A few noble metals, such as gold and platinum, can avoid HER and convert CO₂ to CO. However, these metals are relatively rare and too expensive to serve as cost-efficient catalysts. So, to convert CO₂ to CO in a cost-effective way, scientists used an entirely new form of catalyst. Instead of noble metal nanoparticles, they used single atoms of nickel,” the study highlighted.

Haotian Wang, a Rowland Fellow at Harvard University and the corresponding author on the study, said, “Nickel metal, in bulk, has rarely been selected as a promising candidate for converting CO₂ to CO.”

The study, however, said that “single atoms of nickel produce a different result”.

“Single atoms prefer to produce CO, rather than performing the competing HER, because the surface of a bulk metal is very different from individual atoms,” Stavitski added.

The study stressed that the scientists discovered that “single nickel atoms catalyzed the CO₂ conversion reaction with a maximal of 97% efficiency” and according to scientists, “this is a major step toward recycling CO₂ for usable energy and chemicals.”

“To apply this technology to real applications in the future, we are currently aimed at producing this single atom catalyst in a cheap and large-scale way, while improving its performance and maintaining its efficiency,” Wang added.

‘Seven districts prone to heatwave’

The Indian Meteorological Department (IMD) has warned of severe heat and heatwave conditions in many mandals in Andhra Pradesh this summer.

The officials cautioned that the temperature may cross 45° Celsius in many places, and asked people to take steps to prevent sunstroke deaths. Andhra Pradesh State Disaster Management Authority (APSDMA) Relief Commissioner M.V. Seshagiri Rao released the brochures on dos and don'ts during summer.

In a joint press conference organised here, Mr. Rao and officials of the IMD, AP Space Applications Centre (APSAC) and A.P. State Development Planning Society (APSDPS) warned that seven districts in the State are likely to face severe heatwave conditions.

“Andhra Pradesh experienced intensive heatwave for three weeks during 2015, 2016 and 2017, and more than 45°C heat and heatwaves were recorded in many mandals, and moderate heat was recorded in other places. This year, 52% chances are there to have normal and

above normal heatwave conditions in coastal Andhra Pradesh in the next three months,” IMD Director and scientist Y.K. Reddy said.

40 days

This year, an average of one degree centigrade and above temperatures and heatwaves are likely to occur for about 40 days, Mr. Reddy said and advised people to go in for cool roofs, maintain phone numbers of the doctors and Primary Health Centres (PHCs) and check dehydration every day.

“Prakasam, Nellore, East and West Godavari, Guntur, Krishna and Visakhapatnam districts are prone to heatwave in 2018. Heatwave may occur severely if low pressure is formed,” the Director said.

APSDPS Senior Project Manager P.V. Ramana Murthy explained that Heatwave Action Plan-2018 has been prepared and communicated to all district Collectors and the line departments.

“A State Emergency Operation Centre and State-level Heatwave Monitoring Cell was opened at APSDMA Office. IMD will release forecast and warnings every day,” Mr. Murthy said.

SC seeks details from States on claims to forest lands

The Supreme Court has ordered State governments to provide details of the number of claims for the grant of land under the provisions of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act of 2006.

A Bench of Justices Madan B. Lokur, Kurian Joseph and Deepak Gupta, on a batch of petitions including that of Wildlife First, said it wanted updated information on claims to forest lands, encroachments and evictions.

The court said the claims for grant of land should be those made by the Scheduled Tribes and separately by other traditional forest dwellers, along with the number of claims rejected by States in respect of each category. It called for information on the extent of land over which such claims were made, number of rejections in respect of each of the two categories and the action taken against those claimants whose claims were rejected.

The court, in its March 7 order, asked for the status of eviction of those claimants whose claims were rejected and the total extent of area from which they were evicted. The States have to provide the extent of the area in respect of which eviction has not yet taken place in respect of rejected claims.

Legislative competence



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

The Bench said it wanted information to be provided in four weeks and listed the matter for hearing on April 18. The court recorded that the petitioners had challenged the constitutional validity of the Act as well as legislative competence of Parliament to enact the statute.

Noting that the forests and wildlife are in a “critical state,” the petitioners have indicated that they would want a performance audit by the Comptroller and Auditor General of India or by any other appropriate authority.

Dead eggs, stillborn turtles found at Versova

A day after Olive Ridley turtles returned to hatch at Versova beach after a 20-year hiatus, the Forest Department is looking into the possibility of more turtle nests being present at the beach.

Among the 97 eggs that were found in a four-foot deep pit at the beach on March 22, 84 eggs hatched of which four turtles were stillborn. The remaining 13 eggs didn't hatch at all.

The Forest Department took the dead turtles and unhatched eggs to conduct further lab tests to ascertain the cause of death. Additional Principal Chief Conservator of Forest, Vasudevan N. said, “The mortality rate is usually up to 10% and is likely to go up due to genetic issues. External factors don't really result in the death of the turtles.” Mr. Vasudevan said the dead turtles and unhatched eggs were found evening. “The possibility of having more pits at the beach is quite likely. We have deployed some officials at the site to look into it,” he said. All eggs were found in one pit suggesting they belonged to a single turtle.

Sundarbans mangroves struggle to find new ground

The India State of Forest Report (SFR) 2017 published recently has revealed that the mangrove cover in the country has increased by 181 sq. km. But the Indian Sundarbans that comprise almost 43% of total mangrove cover have shown only a marginal rise of 8 sq. km., at 2,114 sq. km. from 2,106 sq.km. in the 2015 SFR report. This is in spite of large scale planting of mangroves by the State Forest department and NGOs over many years. The latest figures raise the question of whether an enhanced human pressure on the only mangrove forest that harbours a healthy tiger population is affecting the ecosystem.

Unlike the rest of the country, large areas of mangrove forest in the Indian Sundarbans fall under the Sunderban

Tiger Reserve where human activities are prohibited. The Indian part of the Sundarbans covers 4,263 sq. km. out of which 2,584 sq. km. is core and buffer area of the tiger reserve.

A detailed understanding of the threat to the mangroves of Indian Sundarbans has been highlighted in a ‘State of Art Report on Biodiversity in Indian Sundarbans’ published by World Wide Fund for Nature, India (WWF).

The publication reveals that along with climate change, the mangroves are threatened by habitat degradation due to industrial pollution and human disturbance, fuel-wood collection and lack of any high elevation spaces for the mangrove species to regenerate and thrive.

The report states that it is a matter of concern that if the present rates of change prevail, the Sundarbans mangroves could disappear as the sea level rises. This is because the forest's natural response to retreat further inland is blocked by geographical features and man-made obstructions.

Experts like former director of Sundarban Tiger Reserve and a specialist in mangrove conservation, Subrat Mukherjee, and botanists like P. Venu, Neera Sen Sarkar and Anirban Saha who have authored the chapter on Mangroves & Associated Flora put the number of mangrove and associated flora species in the region at 180.

New mangrove areas

The authors have suggested a “rehabilitation of former mangrove areas and creation of new mangrove habitations through intensified afforestation programmes.”

Ratul Saha of the WWF, one of the authors of the publication, pointed out that the threat to each mangrove species varies in magnitude and it is important to fill these knowledge gaps through more research.

Of the 180 mangrove and associated species or halophytes (plants adapted to growing in saline conditions), 34 are true mangroves, of which 19 are major mangroves and 15, minor mangroves.

The species diversity of halophytes of Indian Sundarbans is recorded as 71 mangrove associates, 30 back mangroves, six species of epiphytes and parasites, 23 grass and sedges, four ferns and 12 herbaceous plants.

Mangroves are classified as plants having salt tolerance mechanisms like salt glands, aerial roots in the form of pneumatophores and viviparous germination (germinating before detaching from parent).

They grow mostly in the inter-tidal spaces and are dispersed by water buoyant propagules (seeds or spores).

There are several prominent mangrove species.

Heritiera fomes or Sundari trees from which the Sundar-



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

bans draws its name, has a very restricted distribution in South Asia and is classified as Endangered in the IUCN Red list.

The publication lists five species of mangroves whose status, as per the IUCN Red List, ranges from Near Threatened to Critically Endangered. *Sonneratiagriffithii*, one of the tallest trees of the Sundarbans referred to as Keora by locals is critically endangered while *Ceriops-decandra* (Goran) is Near Threatened. *C. decandra* and *Avicennia* (locally known as Bain) are gathered in violation of law for supplementing fuel wood requirements by the residents.

Species like *Xylocarpusgranatum*, which has a traditional medicinal use in treatment of cholera, diarrhoea and fever is also one of the species which faces threat due to illegal felling.

Among the many associates of mangrove, which grow as climbers and shrubs, some are used for firewood. The other categories of flora, back mangroves, are not found in inter-tidal areas colonised by true mangroves. *Excoecariaagallocha*, commonly called Gorla found towards the mainland along the small canal is one common example.

Among the salt marshes of Sundarbans, *Sesuviumportulacastrum*, with thick, fleshy leaves borne on succulent, reddish-green stems is a pioneer species. Salt marshes are found hosting the mangrove fern *Acrostichumaureum*.

Orchids disappear

The WWF publication points that among the twelve orchid species reported in the past from Sundarbans, most can no longer be found.

Climate change is being attributed to the decline of mangrove species worldwide and the authors emphasise the importance of involving the local population in conservation, keeping in mind the limited livelihood options and the extreme climate events that they have to grapple with. The population density of the Indian Sundarbans outside the Tiger Reserve area is 1,000 people per sq. km., and there is high malnourishment reported from here.

Ajanta Dey, joint secretary of Nature Environment and Wildlife Society, an NGO working for mangrove conservation, said that over the past few years, 4,000 hectares of mangroves were planted by the organisation in the Sundarbans.

Cleared for fisheries

Ms. Dey said illegal clearing of forests for fisheries has turned out to be a major issue over the past few years. She said that large areas in North 24 Parganas have been cleared for fisheries, and as per the report, only 26

sq. km. of mangroves remain there. South 24 Parganas district which has the highest mangrove area of 2,084 sq. km. has only shown an increase of 7 sq. km.

Nationally, the SFR 2017 report estimates the maximum increase of mangrove cover from three States, Maharashtra, Andhra Pradesh and Gujarat.

While the maximum increase of 82 sq. km. has been recorded in Maharashtra, where Thane district alone has witnessed an increase of 31 sq. km., Raigarh has 29 sq. km. and Mumbai Suburban, 16 sq. km..

Andhra Pradesh has seen a rise of 37 sq. km. in the SFR survey, done every two years, with districts like Guntur and Krishna contributing the most.

Gujarat's tally rose by 33 sq. km. in Bhavnagar, Junagarh, Kutch and Jamnagar districts.

In all three States, the increase has been attributed to plantation and regeneration.

Tamil Nadu found an increase of 2 sq. km. of mangroves, taking the extent of such forests to 49 sq. km, as recorded in the FSR report.

Among the striking features of Tamil Nadu's efforts is that Nagapattinam district recorded a decrease of 16 sq. km. while Tiruvarur district posted a rise of 16 sq. km.

Districts like Cuddalore, Pudukkottai and Thoothukudi also have recorded a small increase of 1 sq. km. of mangrove cover each, compared to 2015.

Ramanathapuram district found its cover decreasing by one sq. km.

Crossings: tigers in 26 reserves under threat

The team found that if unplanned development continued, it could result in a 56% higher average extinction probability for tigers within protected areas, due to lack of genetic connectivity.

"If the same rate of landscape change as we have seen for the past 12 years continues, small tiger populations like the ones in Bor and Tipeswar Wildlife Sanctuary are unlikely to survive into the next century," says author Prachi Thatte from NCBS. "Isolated populations – like the one in Panna – are also likely to go extinct."

But new roads in protected areas affect and road widening attract more traffic. In 2001, scientists studying a 9-km stretch of NH 7 which passes through Pench Tiger Reserve in Madhya Pradesh recorded 490 snakes killed in just two years.

In the south, wildlife biologist Sanjay Gubbi and his colleagues studied the impact of vehicular traffic on the use of road edges by large mammals along the Mysore - Mananthavadi highway, which passes through Nagara-

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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

hole Tiger Reserve seven years ago. Camera traps kept on two consecutive sections of the same highway – one closed to vehicular traffic and the other open to vehicles only during the day – the team found that spotted deer, Indian gaur and elephants frequented the segment with higher vehicular traffic density far less, suggesting that they avoid busy highways.

Rituals and roadkills

Scientists found some years ago that religious tourism, which is concentrated across a few months of the year, also killed 56 species on roads passing through the KalakadMundanthurai Tiger Reserve; they recorded a 299% increase in roadkills and a 648% increase in deaths of nocturnal species during this period over the baseline. Conservationists also write about how poachers in south India confessed to illegally hunting deer – including tiger prey like spotted deer – in Bandipur, Bhadra and Bili-girirangaswamy Tiger Reserves by driving on roads at night.

In 2008, night traffic was stopped on a 27-km stretch of the Mysore-Mananthavady Highway within Nagarhole National Park; in a first for India, authorities also re-aligned the highway out of the protected area, and invested in repairing the alternative route in 2012. Now, Tamil Nadu's Mudumalai Tiger Reserve and Gujarat's Gir National Park and Velavadar Wildlife Sanctuary have also either diverted roads or implemented night closure. "Closing roads at night will certainly ensure lower casualties," says Mr. Gubbi. However, options for emergency commuters have to be provided, he adds. "Some compromises are necessary, along with science, outreach and logic."

Roads and widening projects in wild habitats exacerbate what scientists call 'edge effects': this alters plant communities (such as aiding the spread of invasive exotic species like Lantana camara) due to the disturbance along road edges. It can also change animal behaviour. In Tamil Nadu's Valparai, the endangered Lion-tailed macaque was a frequent victim of roadkills on the narrow hill roads weaving through coffee and tea states, till 2011. Today, they cross the roads overhead, using seven canopy bridges installed by the Nature Conservation Foundation and the Forest Department in the Puduthotham and Varattuparai estates. Speed breakers also slow down speeding vehicles.

States like Maharashtra, where Bajirao was killed, need other remedial measures: NH-6 and NH-7 intersect at least six tiger corridors in the Vidarbha region alone. In 2016, WII charted out guidelines for mitigation — such as creating underpasses and planting vegetation — to

be followed while implementing new road projects. The National Tiger Conservation Authority has already prescribed the implementation of some of these on NH-6 and NH-7 to the NHAI, says Debabrata Swain, Director, NTCA.

"On NH-7, flyovers for traffic to facilitate underpasses for wildlife are under construction and will be ready soon," he says. "Measures on NH-6 are also being implemented." However, these will not offer relief on existing roads; they can be added only to new roads or those that are widened, says Maharashtra Forest Department's Chief Wildlife Warden A.K. Mishra.

Cyclone Ockhi takes a toll on Olive Ridleys too

Cyclone Ockhi which battered coastal Kerala has adversely affected the nesting of the endangered Olive Ridley turtles along the Thottappally coast, one of the prime locations for egg-laying turtles in the State.

Secretary of the Green Roots Nature Conservation Forum SajiJayamohantoldThe Hindu that 800 metres of the Thottappally coast used by Olive Ridleys to lay eggs had been destroyed following sea erosion.

"The turtles used to generally nest in an area of around 800 metres north of the estuary at Thottappally but its natural habitat had almost completely vanished in the cyclone. Last year, we stumbled upon four nests on the Thottappally coast. However, not a single nest has been found in the area after the cyclone. The long seawall is also preventing the turtle from nesting in the area," Mr. Jayamohan said.

He said the turtles seemed to be moving to the nearby Pallana beach, south of the estuary. "The real impact of the cyclone on turtle nesting will be known in the coming months," he said.

Nests found

Mr. Jayamohan said three nests had been found, all at Pallana, this season. The first batch of 70 hatchlings had already been let into sea. Two clutches, with 140 and 142 eggs, were in hatching stage.

He said the lack of a permanent hatchery and rescue centre was hampering conservation efforts. "It is important to relocate eggs from areas with tidal fluctuations and guard it from stray dogs and other dangers," Mr. Jayamohan said.

"In the initial years it was about preventing people from stealing and eating the eggs. With awareness campaigns and participatory efforts we were able to stop the practice. However, the other threat still lingers on. In a temporary protected hatchery, there is always a chance that the

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

soil above the eggs will become compact. In such a case, hatchlings will get trapped under the sand. Another threat is from the roots of *Ipomoea pes-caprae* (beach morning glory) plant, the growth of which will destroy the nests," Mr. Jayamohan said.

Sumi Joseph, Assistant Conservator of Forest (Social Forestry), said a proposal for constructing a permanent hatchery was under consideration. "We have submitted a proposal to the government. But shortage of funds remains a major hindrance in getting the nod," she said.

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

HEALTH AND MEDICINE

Diabetes induced blindness: AI detection shows clinical promise

An artificial intelligence (AI)-based diagnostic tool for detecting diabetic retinopathy (DR), developed by Google and researchers in India, is showing clinical promise in the Indian setting, according to Rajiv Raman, a senior consultant at Chennai's SankaraNethralaya, one of the country's leading eye hospitals.

Both SankaraNethralaya and Aravind Eye Hospital in Madurai are working with 2,000 patients each to validate the AI diagnostic tool in a clinical setting. Dr Raman confirmed that the sensitivity and specificity of the screening tool is over 90%.

Aravind Eye Hospital is now in the process of incorporating the deep learning system in their telescreening programme, Dr R. Kim, Chief Medical Officer of the hospital told The Hindu.

Advances in the consumer space have found utility in medicine that can be applied readily, Lily Peng, a doctor of medicine turned product manager at Google told a group of reporters at Google's Tokyo offices a few weeks ago. Dr Peng and her colleagues have been working with ophthalmologists in India over the last few years to address DR, the fastest growing cause of blindness worldwide. Some 425 million people have diabetes, and another 352 million are at risk of developing it. In India alone, in 2017, there were more than 70 million cases of diabetes.

Diabetic retinopathy does not have to lead to blindness if the condition is detected early enough. This is done by looking at the retina, where the presence of lesions — which can indicate fluid leakages and bleeding — is used to

determine the condition's severity. A 2016 scientific paper co-authored by Dr Peng, Dr Kim, Dr Raman and others announced that Google had developed an AI system to look at a retinal image and provide a diagnosis — referable DR (i.e., moderate and worse cases of DR), referable macular oedema or both. The tool is based on machine learning, a process by which a computer learns from patterns it identifies in examples fed to it, rather than via programmed rules. The examples in this case were retinal images captured by a fundus camera (a camera with a low powered microscope attached to it).

Training the program

The program's neural network was trained by a process called deep learning, which involved comparing the program's diagnosis for each image with that of the ophthalmological panel and adjusting the parameters of the function to reduce the error margin for each image. This process is repeated for each image until the program can make an accurate diagnosis based on the intensity of pixels in the retinal image.

The algorithm showed similar, in fact slightly better, levels of sensitivity and specificity as a panel of ophthalmologists.

Nevertheless, challenges remain, especially in the Indian context. There is no screening programme for diabetes in India. Those who have diabetes are supposed to have an annual exam, yet, the screening has usually been opportunistic — i.e., if a diabetic comes to the hospital, their retina is screened.

Ground truth

At Google Tokyo, Dr Peng tells us that her team is working on providing 'better ground-truth' and enhancing the 'explainability' of the deep learning diagnostic tool. Better ground-truth refers to more relevant information that is fed to the system with each case; this can help improve the diagnosis (for example, more images of the ret-



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

ina, or a disagreement between the doctors on how to grade the case). 'Explainability' gets the system to provide a 'why' for its diagnosis, for instance, by producing a heatmap that shows the lesions that made it classify a specific case of DR a certain way.

The writer was a guest of Google in Tokyo a few weeks ago.

Indoor air pollution linked to lung, kidney dysfunction

A cross-sectional study of over 400 kitchen workers in Lucknow and Coimbatore showed that almost 50% of them suffered from poor lung functions and microalbuminuria. They also noticed that Coimbatore workers had a higher risk of obstructive lung problems.

The study conducted by researchers from Indian Institute of Toxicology Research (CSIR- IITR) also examined the particulate matter pollution (PM_{2.5} and PM₁) in the kitchen environment and found high concentrations of particulate matter of sizes, volatile organic compounds, carbon monoxide and carbon dioxide. The study was carried out among male workers in Lucknow and Coimbatore and a control group.

Urine and lungs

Though air pollution primarily affects the lungs, it can also affect other microvascular functions via systemic circulation. So the workers were first tested for microalbuminuria. This is a condition in which there is an excess amount of albumin in urine, and this can be used as a marker for kidney diseases. More workers from Lucknow (56%) had higher microalbuminuria than their counterparts in Coimbatore (42%). Fine particulate matter can reach the alveolar epithelium of the lungs, enter the circulatory system and increase the risk of kidney dysfunction. "By conducting various lung function tests, we found that lung abnormalities were higher in south Indian workers. Apart from exposure to

indoor air pollutants, ethnic differences may be the reason. Previous studies have shown south Indians have lower lung function," explains Dr C.N. Kesavachandran from CSIR-IITR and corresponding author of the paper published in Environmental Health.

The researchers found significantly increased systolic blood pressure in the kitchen workers with microalbuminuria in both states. "But no association was observed between systolic blood pressure and microalbuminuria," says Dr Vipin Bihari, former senior principal scientist and consultant at CSIR-IITR.

Air quality

"We found a cocktail of different elements like carbon, magnesium, calcium, aluminum, and iron in its particulate form in the air," says Amarnath Singh, a PhD scholar at CSIR-IITR and first author of the paper.

This study throws light on poor lung function and its inverse relationship with microalbuminuria. The authors say that a follow-up study is necessary to get a more precise measure of the association between the two.

A novel compound to kill cancer cells

Researchers at Kolkata's Indian Association for the Cultivation of Science (IACS) have synthesised a novel compound that shows potent anticancer activity. The porphyrin compound selectively targets and binds to cellular topoisomerase 1 enzyme (which is essential for maintenance of DNA architecture in the cells) found in cancer cells. Since Top1 enzyme is essential for cell replication and transcription from DNA to RNA, inhibition of its activity leads to DNA torsional strain, overproduction of reactive oxygen species, degradation of the DNA and ultimately cell death.

Though the currently available drug and its derivatives and the compound synthesised by IACS researchers target Top1 enzyme, the

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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

pathways are very different, which was validated in both in vitro and ex vivo cellular studies. As a result, even when chemoresistance to currently available drug (camptothecin) sets in, the new compound could be used for effective killing of cancer cells.

“We used knocked-down breast cancer cells where the amount of Top1 enzyme in the cells was less. When challenged with our compound the cytotoxicity was less. This confirms that Top1 in the cell is the target of the compound and overexpression of Top1 by cancer cells will attract more of the compound leading to cell death,” says Prof. BenuBrata Das from the Department of Biological Chemistry at IACS and corresponding author of a paper published in Journal of Medicinal Chemistry.

Before a cell replicates, the Top1 enzyme binds to the DNA, cuts it and unwinds the DNA before rejoining the cut DNA. While the currently available drug inhibits the Top1 enzyme after the DNA has been cut, the porphyrin compound comes into play much earlier by inhibiting the Top1 enzyme from even binding to the DNA.

“Cellular experiments show that the compound acts well before the enzyme can cut the DNA [which is when the currently available drug begins to act]. This gives us confidence that our compound may be effective in patients who are chemoresistant to the existing drug,” Prof. Das says.

Cellular studies using breast cancer cells showed that the compound induced 3-5 fold increase in reactive oxygen species (ROS) in cells. Elevated levels of ROS in a cell can lead to DNA strand breakage. “The breast cancer cells had about 8-fold increase in DNA strand breaks resulting in about 7-fold increase in cell death,” says Subhendu Kumar Das from IACS and first author of the paper.

“Porphyrins are well known to produce in-

creased ROS inside cells. But so far only the cationic and anionic porphyrins have been studied. This is the first time a neutral porphyrin is shown to produce elevated ROS,” says Dr. HarapriyaRath who synthesised the compound. She is from the Department of Inorganic Chemistry at IACS and the other corresponding author.

The compound showed potent cytotoxicity when tested on different cancer cell lines — cervical cancer, ovarian cancer, and colon cancer — while it showed “markedly reduced or no toxicity” in the case of human embryonic kidney cell lines and mouse embryonic fibroblasts.

While the synthesised compound can also be taken up by healthy cells, the uptake is more in the case of cancer cells. “Studies show that our compound is a potential anticancer agent. More studies are needed to confirm the lab results,” he says.

IISc researchers overthrow cancer metastasis dogma

Researchers at Bengaluru’s Indian Institute of Science (IISc) have uncovered a novel molecular mechanism by which cancer cells survive during the time they are in circulation after detaching from the primary cancer site and before they could attach to the extracellular matrix at a different site and restart cell division, thus causing cancer metastasis. In the process, the team led by Prof. AnnapoorniRangarajan from the Department of Molecular Reproduction, Development and Genetics has identified two potential drug targets to prevent metastasis. The results were published in the journal Cancer Research.

Prof. Rangarajan’s team had a decade ago found that a particular protein called the AMP-activated protein kinase (AMPK) gets activated when cancer cells detach from the extracel-



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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

lular matrix. Now, the team got headlong into researching its connection with another protein kinase called Akt (protein kinase B) as other cancer researchers had all along highlighted how critical Akt was for cancer cells to survive. It was always thought that the AMPK protein suppresses tumour growth while Akt behaves as a promoter. “But what we saw in our study was a complete reverse, which was a surprise. We found AMPK getting activated in circulating cancer cells and, in turn, suppressing the Akt activity,” says Prof. Rangarajan. “The AMPK-mediated Akt inhibition is necessary for cancer cells to survive during circulation.” The AMPK that gets activated in circulating cancer cells keeps them alive at the cost of cell division. Once the circulating cancer cells reattach to the extracellular matrix at a distant site from the primary tumour, Akt gets reactivated and AMPK gets inhibited. The protein Akt is required for cell growth and proliferation while AMPK is needed for growth suppression.

“Our study based on breast cancer cells has refuted the 20-year-old dogma that Akt is vital for the survival of circulating cancer cells,” she says proudly. “We have established that there is a role-reversal of Akt and AMPK proteins in breast cancer progression.”

No link between Akt and AMPK proteins in cancer metastasis was known till now. The results of the latest study, therefore, become all the more important.

Drug targets

The AMPK-mediated inhibition of Akt is through increased levels of a phosphatase (PHLPP2), which removes the phosphate group from Akt. “The PHLPP2 was also believed to suppress tumour. But in circulating cancer cells, PHLPP2 also becomes a tumour promoter,” Prof. Rangarajan says. “So molecules that inhibit AMPK

and PHLPP2 can be developed as effective anti-metastasis agents,” she says.

“We used mouse models to support our findings from cancer cell lines. Since there are no chemicals available to inhibit PHLPP2, we used a RNA interference strategy to reduce PHLPP2 levels. This resulted in impairment of the metastatic potential of cancer cells,” says Dr. ManipaSaha from the Department of Molecular Reproduction, Development and Genetics and first author of the paper.

“Our work focuses mainly on breast cancer cells as the first observation of AMPK-Akt crosstalk was made in these cells in our laboratory. However, our results on mechanistic details of the inverse crosstalk are expected to hold true in other cancer cells. But more research is needed to confirm this,” says Saurav Kumar, a coauthor of the paper.

Metformin caution

The diabetic drug metformin has been repurposed as an anticancer agent. “Since metformin activates AMPK, treatment using this drug may actually promote metastasis. So metformin should not be used for cancer treatment without fully understanding its side-effects,” Prof. Rangarajan warns.

IISc team identifies an early-stage biomarker for Alzheimer’s

Researchers at Bengaluru’s Indian Institute of Science (IISc) have identified a potential biomarker for Alzheimer’s disease. The biomarker shows up very early in the disease process and well before clinical and even pathological manifestation of the disease. They also found that it is possible to reverse the disease process if identified early.

Loss of dendritic spines from the surface of a nerve cell is already recognised as an early feature of Alzheimer’s. But the underlying mecha-



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

nism behind this loss was not known. Now, a team led by Vijayalakshmi Ravindranath from the Centre for Neuroscience at IISc has deciphered it. The results were published in Journal of Neuroscience.

Projections on the dendrites called spines grow or shrink in response to activity-dependent modification and correlates with normal memory or memory deficit in animal models.

Filamentous actin (F-actin) is a cytoskeletal protein which is responsible for maintaining the shape of the spines. While F-actin is formed by polymerisation of monomeric globular-actin (G-actin), depolymerisation leads to loss of F-actin and, in turn, the loss of spines. F-actin is crucial for memory consolidation.

"In mice that are genetically altered to have Alzheimer's, there was decreased F-actin protein level and increased G-actin protein level in animals as young as one month," says Reddy Peera Kommaddi, a DBT-Ramalingaswami Fellow, from the Centre for Neuroscience at IISc and first author of the paper. The change in the ratio of F-actin and G-actin led to loss of spines. The decrease in F-actin level and loss of spine thereof translated into memory deficit when the animals turned two months old.

In contrast, the first signs of memory deficit in mice with Alzheimer's is typically seen only when the animals are seven-eight months old. This is because the formation of protein clumps called amyloid plaques, which is one of the earliest clinical symptoms, happens at this stage.

Testing memory

To test the role of F-actin in behaviour response, two-month-old mice were exposed to mild foot shocks when kept in a conditioning chamber to bring about contextual fear conditioning. While normal mice placed in the chamber the next day they tend to freeze in anticipation of a shock, mice with Alzheimer's did not exhibit this be-

haviour. "The Alzheimer mice did not associate the aversive event [electric shock] with context but simply kept exploring the chamber," says Smitha Karunakaran from the Centre for Brain Research at IISc and a coauthor of the paper.

To test if decrease in F-actin protein and, in turn, the spine was responsible for deficit in memory a chemical was injected into Alzheimer mice to stabilise the level of F-actin. "A day after the injection, the F-actin level was restored to normal level and the Alzheimer mice showed increased freezing response just like healthy mice," says Dr Karunakaran.

The researchers went a step further to test the role of F-actin level in behaviour response by injecting a chemical into four-month-old normal mice. Since the chemical inhibits actin polymerisation, there was a decrease in the F-actin level. And the mice, though healthy, displayed significant decrease in freezing response, just like Alzheimer's mice would behave.

"These two experiments conclusively proved that loss in F-actin level leads to early behavioural changes that would eventually lead to Alzheimer's disease," says Dr. Kommaddi.

The team checked the level of F-actin levels in cortical brain tissue samples of human subjects who had Alzheimer's, mild cognitive impairment and normal cognition. There was "graded lowering" of F-actin levels from normal to mild cognitive to Alzheimer's tissue samples.

The correlation seen between mouse model and human disease indicates the potential to use F-actin levels as a biomarker.

Dual mechanism for embryonic stem cells to maintain pluripotency

Embryonic stem cells are capable of generating all the cell types that compose the organs and systems of the human body. Now, researchers at Pune's National Centre for Cell Science



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

(NCCS) have found a dual mechanism that keeps specific genes off, which helps the embryonic stem cells maintain pluripotency — their ability to give rise to all the cell types. The dual mechanism functions in such a way that even if one mechanism fails, the other can function as a back-up and help the embryonic stem cells maintain pluripotency.

Role of endocytosis

Embryonic stem cells contain multiple endocytosis-associated genes whose expression is suppressed unlike in the case of the specialised or differentiated cells. Some of the genes are directly responsible for or involved in the regulation of the transport of molecules present on the cell surface membrane to the interior of the cell. The precise mechanism by which the expression of endocytosis-associated genes are turned off in embryonic stem cells and the role of endocytosis (transport of molecules from the membrane surface to inside the cell) in maintaining pluripotency was not known. A team led by Dr Deepa Subramanyam from NCCS has deciphered them. The results were published in the journal Scientific Reports.

“We attempted to identify and ascertain if certain genes that are associated with endocytosis have their expression kept under check or not in stem cells, and if these genes had any role in maintaining the stemness of embryonic stem cells,” says DrSubramanyam.

Two pathways

The team identified two pathways — polycomb repressive complex (PRC2) and embryonic stem cell-specific cell cycle (ESCC) regulating microRNAs — that suppressed the expression of the endocytosis-associated genes in embryonic stem cells but not in cells that have already differentiated. While the expression of 50 endocytosis-associated genes is kept under check by one pathway (PRC2), the expression of a

smaller subset of 12 genes is also reduced by the action of the second pathway (ESCC).

The PRC2 complex has four subunits, and when one particular subunit (Ezh2) was knocked down it led to significant increase in the expression of endocytosis-associated genes. Similar results were obtained when another subunit (Suz12) was knocked down.

MicroRNA

Stem cells have a class of small non-coding microRNAs called the ESCC-family of microRNAs. The microRNAs work by binding to the complementary sites seen on messenger RNA (mRNA). “Of the 50 endocytosis-associated genes, 21 genes had complementary sites for the microRNA, indicating that these 21 could potentially be controlled by microRNAs,” she says.

“The function of the PRC2 complex is to suppress the expression of the 50 endocytosis-associated genes. And the microRNAs function as a back-up, in case the expression of some of the genes is not completely shut down by the action of the PRC2 complex,” says DrSubramanyam. The stem cells will continue to exhibit pluripotency as long as the expression of the endocytosis-associated genes is turned off. To confirm that the genes have to necessarily be turned off for pluripotency to be maintained in stem cells, the researchers introduced the genes into stem cells in such a manner that the expression of these genes was not turned in the stem cells. “We introduced only one gene at a time and we tested a total of two genes. In both cases, the embryonic stem cells began losing their pluripotency and there was an upregulation of differentiation markers,” says RidimDadasaheb Mote from NCCS and first author of the paper.

“Our work will be helpful in regenerative medicine. Understanding the pathways and mecha-



aspirantforum.com

Science and Tech.

The Crux of The Hindu

Vol. 13

News of Jan-Mar18

nism of endocytosis can now give us a handle to try and convert induced pluripotent stem (iPS) cells, which are pluripotent, into specialised cells, such as neurons, by altering the expression of the endocytosis-associated genes,” says DrSubramanyam.



Saliva prevents traveller's diarrhoea: study

Scientists in the U.S. have identified a protein in saliva (histatin-5) that protects the body from traveller's diarrhoea. The finding, published in the Journal of Infectious Diseases, may lead to the development of new preventive therapies for the disease.

Traveller's diarrhoea can be deadly. It produces a watery diarrhoea, which can cause life-threatening dehydration in infants or other vulnerable populations in endemic countries. Hundreds of thousands of deaths can be attributed to this bacterial disease which is caused by enterotoxigenic Escherichia coli (ETEC), invading the small intestine using arm-like structures called “pili”, according to the study.

This new finding opens up the possibility that other salivary proteins might exist which protect against many other diseases, including infectious gastritis, food poisoning or even pneumonia.

Vitamin B12 supplements may reduce diabetes risk

Researchers from CSIR-Centre for Cellular and Molecular Biology (CCMB), Hyderabad along with scientists from Pune, Singapore and UK studied the molecular pathway to understand how B12 supplements are associated with Type

2 diabetes and its associated genes.

“Previous studies from our lab have shown that B12 supplementation for a year was able to bring down the level of homocysteine (a marker for cardiovascular diseases). We wanted to explore further as we know that B12 plays an important role in many reactions of the body and influences risk for many diseases including cardio-metabolic disorders,” says Dr. Giriraj R. Chandak, scientist at CSIR-CCMB and corresponding author of the paper published in Epigenomics.

The study involved 108 children from the Pune maternal nutrition study (PMNS). The children were randomly divided into four groups. One group was not given any supplements while the second was given B12 supplements (10 microgram/day), third B12 with folic acid (known to influence homocysteine levels) and fourth only folic acid.

After a year, their blood samples were collected and genomic DNA was isolated and studied for differences before and after supplementation.

Crucial factor

“We found that B12 was a crucial factor in the one-carbon metabolic cycle of the body which determines the levels of different proteins by regulating methylation of their genes. The expression of various genes associated with diabetes was found to be less by methylation. We found four top genes that were associated with diabetes to be less expressed,” he adds.

“Studies are ongoing in the lab to understand more about how B12 affects the molecular network and signaling pathway of the genes associated with Type 2 diabetes,” says DrSmeeta Shrestha, postdoctoral fellow and coauthor from CCMB. “Almost 40-70% of the Indian population is vitamin B12 deficient. But this study clearly provides evidence that a micronutrient can immensely influence the risk for a com-



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

monly occurring disease like diabetes,” says Dr. Chandak.

IIT Guwahati develops silk scaffold for bone regeneration

A scaffold made of silk composite functionalised with copper-doped bioactive glass to facilitate faster bone regeneration has been developed by researchers at Indian Institute of Technology (IIT) Guwahati. The scaffold seeded with stem cells was found to differentiate into bone cells, facilitate growth of blood vessels and successfully integrate the newly formed bone cells with the native bone.

The researchers were able to replicate the results in rabbits using functionalised non-mulberry silk composite. Rabbits with scaffolds implanted at the site of bone injury showed successful growth of bone cells and integration with the native bone at the end of three months. Commercially available synthetic grafts have a failure rate of about 25% and 30-60% complication rates. This is due to slower bonding with native bone and poor blood vessel growth.

The team led by Prof. Biman Mandal from the Department of Bioscience and Bioengineering at IIT Guwahati developed the silk composite by adding chopped silk fibre to liquid silk. Unlike pure silk, the silk composite has greater strength. The addition of bioglass further enhanced the strength of the composite.

Besides other kinds, both mulberry and non-mulberry silk composites were tested. The non-mulberry silk composite was found to be superior in all respects. The RGD sequence in non-mulberry silk is a cell binding site and helps in better cell attachment and proliferation. As a result, more stem cells get attached to the composite leading to better bone tissue formation with time.

Suitably rough

Besides enhancing the strength of the compos-

ite, the minerals from the bioglass gets deposited on the composite making it rougher. “Bone cells prefer rough surfaces and the scaffold mimics the native bone surface architecture,” says Prof. Mandal. Bioglass also helps in stem differentiation. “We found stem cells differentiating into bone cells with the formation of extracellular matrix similar to natural bone,” he says.

Doped copper

The doped copper plays a crucial role in stabilising the gene responsible for blood vessel formation. The gene, in turn, regulates the downstream angiogenic factors thus helping blood vessel formation.

Copper also plays a role in attracting endothelial cells (which forms the inner lining of blood vessels) present nearby to the bone defect site making blood vessel formation possible.

The mulberry silk composite degrades and gets desorbed by the body at a faster rate than the non-mulberry silk. The rate of silk composite degradation should match the rate of new tissue formation else the bone that forms will tend to be weaker. “The non-mulberry silk material will be replaced completely in a few years. Since bone healing is slow, the silk material should not degrade quickly,” Prof. Mandal says.

The researchers tested the potential of the composites in repairing bone defects in rabbits and found more than 80% bone formation at the end of 30 days. “In the rabbits, the scaffolds promoted new bone tissue formation and growth of blood vessels. The resorbable nature of the scaffolds enabled them to degrade inside the body while being replaced with viable bone tissue in the small focal sized bone defects. No remnants of the scaffold were seen,” says Joseph Christakiran Moses from the institute’s Department of Bioscience and Bioengineering and first author of a paper published in the journal *Advanced Healthcare Materials*.



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

“The results from rabbit models are very promising. We would like to undertake trials on larger animals such as sheep and goat,” says Prof. Mandal. “Since we use green methodology, the prospects of regulatory clearance are brighter.”

Nanomotors for targeted cancer therapy

Research on nanomotors for various medical applications is an emerging field in nanoscience and researchers from Indian Institute of Science (IISc), Bengaluru, have had a measure of success.

The researchers have developed a new type of zinc-ferrite-coated magnetic nanomotors that are highly stable and can generate localised heating to kill cancerous cells. The results were published in *Nanoscale*.

Just 3 microns

Measuring just about 3 microns in size, the magnetic nanomotors can be manoeuvred in different biological environments like blood, tissue etc using rotating magnetic fields of less than hundred Gauss (safe level for human beings) and targeted to the area of interest in the body. They are popular due to their non-invasive nature and the absence of the need for chemical fuel to propel them.

“We can inject these ferric nanomotors directly into the tumour or guide them to the area of interest using magnetic fields,” says LekshmyVenugopalan, Research Associate at IISc’s Centre for Nano Science and Engineering and first author of the paper.

Hyperthermia experiments were carried out using these nanomotors on human cervical cancer cells in the lab. “On applying the appropriate magnetic field and frequency for about 20 minutes the temperature rises by 7-8 degrees Celsius — the window of cell death. The generated heat was high enough to kill the cancerous cells,” adds Lekshmy. Nanomotors of 2 mg/

ml caused about 50% cell death in 20 minutes. “The nanomotors are biocompatible and in vivo studies are being carried out to understand how it will be processed in the body.”

“The current limitations of cancer therapies including inaccessible locations in the body and drug resistant tumours could be overcome with such tiny heat-generating motors irrespective of the type of cancer,” says Shilpee Jain, DST INSPIRE faculty fellow at the institute and co-author of the paper.

Shows potential

Silicon dioxide forms the backbone of these nanomotors and magnetic material such as iron is deposited on top of it. The zinc ferrite coating is then applied to provide multifunctional properties such as enhanced physical and chemical stabilities, and magnetic hyperthermia potential. “These new developments have sorted out some long-standing technological issues like agglomeration of the nanomotors,” says Ambaish Ghosh, corresponding author of the paper. “Future research in this area would be directed towards in vivo experiments. More studies on combining drug release with magnetic hyperthermia need to be carried out.

“The targeted therapy could have great implications for cancer therapeutics.”

WHO launches plan for cheaper TB drugs

The World Health Organization (WHO), invited pharmaceutical companies around the world to submit proposals to manufacture affordable versions of newer medicines for treatment of drug resistant tuberculosis.

A WHO spokesman said the aim was to replicate the success of addressing the HIV epidemic. Competition among Indian drug producers had then brought down the price of HIV medicines by 99% from \$15,000 per patient per



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

year to less than a dollar a day.

WHO has now requested drug makers to submit an Expression of Interest (EoI) for Bedaquiline and Delaminid, two new-generation drugs, recommended for drug resistant-TB. Under WHO norms, drugs submitted upon such requests and complying with its standards are included in a list for procurement by the UN and other organisations.

India has nearly 1.3 lakh DR-TB patients, the most in the world, but the Health Ministry gets only 10,000 doses of Bedaquiline and 400 doses of Delaminid. The medicines are obtained as donations from Janssen (US) and Otsuka Pharmaceuticals (Japan), the respective manufacturers.

“One of the aims of pre-qualification is to ensure that a greater number of manufacturers are supplying quality medicines, which, in turn, means a more competitive market and more affordable prices. We have seen this with HIV, where the pre-qualification of many predominantly Indian manufactured products brought the price down of many anti-retrovirals. Inclusion within the scope of PQ has also incentivized the development of fixed dose combinations, which have yielded much better results for patients,” said Daniela Bagozzi, communication manager, WHO.

In the case of HIV, one company, Cipla, came up with a ‘AIDS cocktail’ combination of Stavudine, Lamivudine and Nevirapine, enabling effective treatment.

Cheaper drugs to treat HIV became possible at the time as the Indian Patents Act did not provide for product patents on pharmaceutical products, until required by the Trade Related Intellectual Property Rights (TRIPS) framework of the World Trade Organization (WTO). India became TRIPS compliant with pharma product patents in 2005.

Open to generics

“The whole world looks to India to provide access to affordable drugs because of our capabilities. With WHO’s backing, we will be able to accelerate introduction of generics,” said D.G. Shah, secretary general, Indian Pharmaceutical Alliance (IPA).

Inclusion of the two new drugs, Bedaquiline and Delaminid, in the pre-qualification call is being interpreted by aid agency Médecins Sans Frontières (MSF) as WHO’s backing for generics.

Christophe Perrin, pharmacist at MSF, said, “It is clear from the EoI that WHO considers the two drugs key compounds to address challenges of drug-resistant TB. It also means that they want to encourage generic competition to start finding ways to make these medicines available in countries where they are not yet registered. The EoI allows generics manufacturers interested in producing these two drugs, and currently facing technical challenges, to address their questions to WHO’s pre-qualification team.”

Arun Kumar Jha, Economic Advisor, Union Health Ministry, said, “We are not wasting a single moment in ensuring affordable versions of these medicines are scaled up.”

Early menopause a risk: study

A recent UK study published in *Heart*, an international cardiology journal, has indicated that women who start their menstruation cycle at the age of 11 or earlier, or enter menopause before 47, have a higher risk of heart disease and stroke.

According to the study, some other factors that were associated with elevated odds of heart problems in later years were miscarriage, stillbirth, undergoing a hysterectomy, and bearing children at a young age.

The findings of the study led by Sanne A E Peeters from The George Institute for Global Health,



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

University of Oxford, have suggested that women who had premature reproductive cycles or a history of adverse events should be screened for heart problems.

In an email interview, Dr. Peters told The Hindu that the study included 2,67,440 women and 2,15,088 men without a history of cardiovascular disease (CVD) at baseline.

Between 2006 and 2010, the UK Biobank recruited over 5,00,000 participants aged 40–69 years across the UK.

Participants filled in questionnaires on their lifestyle, environment, and medical history, which included their reproductive history.

They were monitored up to March 2016 or until they suffered a first heart attack.

The study found a strong link between women's reproductive health and her risk of cardiovascular problems.

Women who began their periods early, or who had pregnancy complications such as stillbirth or who needed a hysterectomy were also more likely to develop heart issues.

Women who went through menopause before the age of 47 had a 33% heightened risk of cardiovascular disease, rising to 42% for their risk of stroke, according to the study.

Those who entered puberty before the age of 12 were at 10% greater risk of cardiovascular disease than those who had been 13 or older when they started, the study said.

Previous miscarriages were associated with a higher risk of heart disease, with each miscarriage increasing the risk by 6%. Having a stillbirth was associated with a higher risk of cardiovascular disease in general (22%) and of stroke in particular (44%).

During seven years of follow-up, a total of 9,054 incident cases of CVD (34% women), 5,782 cases of coronary heart disease (CHD) (28% women), and 3,489 cases of stroke (43% wom-

en) were recorded among the participants.

“The study was conducted primarily among white British women. Although possible, further studies are needed to establish whether these findings also apply to women in India,” said Dr. Peters.

Frequent screening

The research has suggested that policymakers should consider implementing more frequent screening for cardiovascular disease among women with one or more of the risk factors highlighted here in order to put in place measures that can help delay or prevent the development of heart disease and stroke.

Cardiovascular disease, a general term for conditions affecting the heart or blood vessels, remains the leading cause of death worldwide.

Previous research has suggested that the early onset of periods is linked to obesity, a known risk factor for heart disease in later life.

However the findings of this study showed that the risk of developing cardiovascular disease increased for women even if they had a healthy weight.

The researchers also ruled out smoking, diabetes and high blood pressure as possible causes. Dr. Peters pointed out the need for more research to understand the association between an early first menstrual cycle and a greater risk of heart disease and stroke in later life.

First India-designed vaccine passes WHO test

For the first time, a vaccine conceived and developed from scratch in India has been “pre-qualified” by the World Health Organisation.

The Rotavac vaccine, developed by the Hyderabad-based Bharat Biotech Limited last year, was included in India's national immunisation programme. To be “pre-qualified” means that the vaccine can be sold internationally to



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

several countries in Africa and South America. While several vaccines from India have been pre-qualified, this is the first that was entirely developed locally and, according to experts, is a sign that there is a credible industrial, scientific and regulatory process in place to develop vaccines in India.

The Rotavac vaccine protects against childhood diarrhoea caused by the rotavirus and was built on strain of the virus isolated at the the All India Institute of Medical Sciences here over 30 years ago.

Krishna Ella, chairman and managing director of Bharat Biotech, said that about 9 million children in nine Indian States have been vaccinated.

Some medics have raised concerns that the rotavirus vaccine carried a small chance of causing infants to develop a bowel disorder; but the Rotavac vaccine, having been tested in the field for over a year, have not shown any negative effect, he claimed.

IIT Kanpur team finds possible cause of neurodevelopmental disorders

Bone morphogenetic proteins (BMP) are secreted signalling molecules which are already known to regulate the production of neurons from neural stem cells. Now, using mice models, a team of researchers led by Prof. Jonaki Sen from the Indian Institute of Technology (IIT) Kanpur has found that BMP signalling is active in the cerebral cortex during embryonic development as well as during later stages of development after birth, too.

They found that BMP signalling regulates three processes — the migration of new-born neurons from stem cell niche to their destined place in the cortex, polarity (the axon forming the base and the dendrites forming the apical or top side) of neuronal cells, and branching of dendrites in

the upper layer neurons of the cerebral cortex. The cerebral cortex has six neuronal layers formed in an inside-out manner. The early-born neurons form the inner cortical layers while the late-born neurons form the outermost layers. So any perturbation or delay in the migration of new-born neurons results in disturbed layer formation and lack of proper connectivity between neurons.

Similarly, when polarity (alignment) or branching of dendrites is affected, the neurons will not be able to form proper electrical connections. Though there are other factors that determine migration and polarity, the role of BMP signalling in these two processes was not known till now.

BMP signalling

“BMP signalling was previously known to play an important role in the early development of the brain. Our study is the first to show that BMP signalling plays an important role in cortex development by regulating the migration of new-born cortical neurons and the establishment of polarity in the upper layer of cerebral cortex,” says Dr. Monika Saxena from the Department of Biological Sciences and Bioengineering at IIT Kanpur and first author of the paper published in the journal *Development*.

“There are many neurodevelopmental disorders linked to aberrant migration of neurons such as lissencephaly, autism, epilepsy and schizophrenia,” says Prof. Sen who is with the Department of Biological Sciences and Bioengineering. “We now know that inhibition of BMP signalling leads to delayed migration and this may be one of the causes for such disorders. Thus, it might be possible to prevent or treat these diseases if further research is carried out.”

Two pathways

BMP signalling can be through two pathways — phospho-SMAD or LIM kinases. When BMP



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

signalling was totally inhibited, both the pathways were affected. As a result, all the three processes — migration, polarity and neurons not making enough branches — were affected. To understand the role of each pathway in affecting any of the three stages of neuronal development, the researchers selectively blocked one pathway at a time.

“Both pathways have a role in the migration of neurons. When only one of the pathways was blocked, migration was affected but to a lesser extent than when both pathways were inhibited,” Prof. Sen says.

In the case of polarity, inhibiting the LIM kinase pathway seemed to be less effective than inhibiting the phospho-SMAD pathway. “Using mice models we determined that the phospho-SMAD pathway was more important than LIM kinase pathway for polarity establishment,” Prof. Sen says.

But the reverse was true in the case of the branching of dendrites. Inhibiting the LIM kinase pathway had a greater effect on dendrites branching than inhibiting the phospho-SMAD pathway.

The researchers found that BMP signalling seems to selectively regulate migration of upper-layer neurons. The migration of neurons to form the lower layers, which are the first to be formed, is not affected even when BMP signalling is blocked.

Even when both the pathways of BMP signalling were blocked, migration was only delayed and not completely stopped. But the delay in migration causes problems. “When neurons finally reach the upper layers (layer II/III), they don’t have proper polarity,” Prof. Sen says.

Evidence in mice

The gestation period in the case of mice is 20 days. The migration delay was seen two days after BMP signalling was blocked on gestation

day 15.5 and continued till at least the day of birth. Disturbed polarity was manifested on the sixth day after birth. Defects in dendrite branching was first seen 15 days after birth and fully manifested 21 days after birth.

“BMP signalling is involved in regulating multiple phenomena at different stages of cortex development,” says Prof. Sen.

Honey to heal wounds in diabetics

Honey, a traditional medicine used for thousands of years, has now been proved to heal wounds as well. Researchers from IIT Kharagpur have reported that honey can be used for healing wounds in diabetics.

Treatment of diabetic chronic foot ulcers is an unmet clinical challenge and often leads to disease-associated amputations. In diabetic patients, the micro- and macro-vascular alterations cause nerve damage and tissue hypoxia. The abnormalities in the inflammatory pathways lead to development of infectious non-healing foot wounds. Diabetes also affects the synthesis and alignment of collagen fibres which are the main requirements for wound healing. The research published in Wound Medicine reported that honey improves collagen synthesis thus helping wounds to heal.

Healing honey

“We first characterised the physical and chemical properties of honey. Honey contains amino acids like proline, arginine and glutamic acid. The ascorbic acid in the honey stimulates the quick maturation of collagen fibres needed for wound healing. It can also prevent scarring and minimises hypoxic assaults on cells,” says Dr-Jyotirmoy Chatterjee, Associate Professor at the School of Medical Science and Technology, IIT Kharagpur.

Animal studies have shown that an acidic pH (3.3-3.9) reduces protease activity and increas-



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

es release of oxygen to promote tissue regeneration and growth of fibroblasts. Topical application of honey caused this acidification and this might be responsible for promoting wound healing. Antioxidant content and radical scavenging activities of honey possibly play a crucial role in controlling over production of reactive oxygen species in diabetic wounds and helps in angiogenesis. Imaging studies showed that honey-treated wound bed achieved organised collagen distribution like normal skin.

“Further tests have been carried out using cell culture, in vitro gene expression and in vivo studies on human subjects,” says Dr Chatterjee. The researchers have developed a honey-based film/membrane, which can be used as a wound-healing patch. The patch has been patented.

According to Amrita Chaudhary, one of the authors of the paper, work is one to characterise the bioactive constituents of different Indian honey samples such as polyphenolics and sugar and developing honey-incorporated silk fibroin patch. The patch has nano-patterned and micro-pillar substrates with improved cellular compatibility.

“Honey embedded silk fibroin patch with micro-pillar matrix acts differentially on normal and fibrosis associated fibroblasts,” says Monika Rajput from the lab.

However, the molecular pathway through which the honey endorses collagen regeneration is yet to be investigated.

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

BIOTECHNOLOGY

IICB uncovers molecular mechanism of stress-induced gastric ulcer

Researchers at Kolkata's CSIR-Indian Institute of Chemical Biology (CSIR-IICB) have for the first time identified the molecular mechanism by which acute mental stress affects the stomach causing gastric ulcer or stress-related mucosal disease. Using a rat model subjected to cold-restrained stress, the research team led by UdayBandyopadhyay from the Division of Infectious Diseases and Immunology at IICB has used drugs that can act specifically on mitochondria present in the stomach to prevent gastric ulcer caused by stress.

When subjected to stress, the mitochondrial respiratory capacity was disrupted, ATP production was reduced and oxidative stress increased. Stress also causes morphological changes to the mitochondria such as increased fragmentation. The results of the study were published in the journal *Free Radical Biology and Medicine*.

"Due to oxidative stress and fragmentation, the mitochondria in the gastric mucosal lining cannot behave in a normal fashion and ATP production gets further compromised. In the absence of ATP production, cells cannot proliferate and the gastric lining gets thinner due to mucosal cell death. All these cause stress-induced gastric ulcer," explains Dr. Bandyopadhyay. "This is the first time we could find a link between the mind and mitochondria in the stomach. It is very exciting and fascinating."

Second brain

The stomach is one of the organs most severely affected by stress and this is due to the link between the stomach and the brain. Moreover, the stomach is also known as the body's second brain with a specialised neural network, repository of neurotransmitters and different kinds of nerve cells innervating the organ, though fewer in number.

Plenty of corticosterone was released into the blood when the animals were subjected to stress. Once corticosterone gets inside mitochondria it reduces ATP production and respiration capacity. By using a drug that prevents corticosterone from binding to the receptor found inside the cell, the researchers were able to significantly prevent stomach injury in the animals.

Interestingly, some common psychoactive drugs used in the study helped in preventing the pathological manifestations — gastric ulcer. "So we can say that it is indeed

the acute mental stress which is causing gastric complications," says Rudranil De from IICB and first author of the paper.

Role of mitochondria

"We delved deeper to find out the involvement of mitochondria in stress-induced gastric damage," says De. A compound that scavenges harmful free radicals released from the malfunctioning mitochondria and another compound that inhibits mitochondrial fragmentation significantly prevented the injury and intra-gastric bleeding; although the drugs don't reportedly act on the brain.

"Although stress is present, we could still prevent the damage caused to the stomach by targeting the mitochondria," says De. "The use of these two compounds acting directly on the mitochondria confirmed that acute mental stress damages the mitochondria of the stomach ultimately leading to tissue injury and haemorrhage."

The use of tranquilisers and barbiturates, often prescribed to patients suffering from mental stress and disorders, are associated with inherent problems including withdrawal effects and long-term side effects. "Our study proposes an alternative line of therapeutic strategy which relies on salvaging mitochondrial damage, thereby providing significant protection from stress. This will help avoid the use of existing psychoactive drugs while keeping the subjects alert," says SomnathMazumder from IICB, one of the authors.

If further research and human trials confirm the results seen in animal studies, it would lead to a new generation of anti-stress medications with minimal side effects which would aim at targeting the mitochondrial pathology to take care of a bigger psychosomatic health complication.

How H. pylori bacteria survive in the stomach

An international group of over 50 scientists including three Indians have found out how the bacteria *Helicobacter pylori* survive in highly acidic environment of the human stomach. *H. pylori* causes peptic ulcer, and chronic infection can also lead to gastric cancer.

For the first time, scientists have found that the binding of the bacteria to the stomach mucosal layer is acid-sensitive, allowing it to attach and detach when needed. The bacteria bind to the mildly acidic (pH 6) mucous layer of the stomach and when the mucous is shed into the highly acidic (pH 2) stomach, the bacteria quickly unbinds and moves to a fresh mucous layer site. The results were published in *Cell Host & Microbe*.

Breakable binding

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

Previous studies have shown that the bacteria tightly attach to the epithelial cells and mucous of the stomach with the help of an adhesin called BabA. But now the researchers found that though tightly bound to the mucous, the binding affinity reduces once the bacteria sense more acidic pH (2-4 pH). The mucous lining of the stomach is constantly shed into the stomach, which is highly acidic compared with the mucous layer.

The scientists found a 2- and 20-fold less binding at pH 4 and 2, respectively, compared to pH 6. Within 30 seconds, 85% of the bacteria detached from the mucous layer when placed in a strong acid. They also saw that 95% of them recovered binding activity when shifted to less acidic site.

"Such a pH-dependent, reciprocal attachment-detachment system should be a great advantage for long-term colonization in the stomach. Indeed, its importance is supported by the extensive microevolution of BabA," Dr. Asish K. Mukhopadhyay from the National Institute of Cholera and Enteric Diseases (NICED), Kolkata says in an e-mail to The Hindu.

In order to know the exact pH at which bacteria loses binding, they tested 21 Swedish bacteria isolates. They found that that the bacteria detached at pH ranging from 2.3 to 4.9 showing that they can adapt to individual acid secretion patterns.

H. pylori is associated with low stomach acidity in Peru but higher acidity in Indians. The scientists carried out further studies to understand how Indian strains were more acid tolerant. They found that in order to escape the acid, the Indian strains attach to the end or bottom of the stomach.

Dr. Mukhopadhyay pointed out that future studies are required to fully understand the molecular mechanisms behind the Indian bacterial strains, and knowing how the bacteria attach and detach can help develop alternative medical aid for stomach diseases and rethink acid-suppression therapies.

IGIB discovers a protein regulating melanoma growth, pigmentation

Researchers at Delhi's CSIR-Institute of Genomics and Integrative Biology (IGIB) have for the first time identified a calcium sensor protein (STIM1) that independently regulates both skin cancer and pigmentation. The STIM1 protein does so by activating two independent signalling pathways.

Interestingly, different parts of the STIM1 protein activate the two independent signalling pathways that control

melanoma growth and pigmentation. This opens up the possibility of developing drug molecules that target specific sites in the STIM1 protein to control tumour growth and regulate pigmentation.

While skin cancers account for third highest number of cancer associated deaths worldwide, perturbations in pigmentation pathways result in pigmentation disorders such as solar lentigo, melasma, vitiligo, and pityriasis alba. Current therapeutic regimes are not efficient in alleviating pigmentation disorders.

Role of STIM1

"The role of STIM1 in breast cancer and prostate cancer is already known. Based on this, we hypothesised that STIM1 might have a role in melanoma growth as well," says Dr. Rajender K Motiani from the Systems Biology Group at IGIB who led the team of researchers.

To study the role of STIM1 protein in melanoma growth in vitro, the researchers used STIM1 knockdown mouse cells and injected them into mouse models and observed the growth of melanoma. Compared with controls, melanoma growth was reduced by as much as 75% in mice that were injected with STIM1 knockdown cells.

While trying to find novel players that could potentially regulate pigmentation, the researchers identified a few signalling pathways which were differently regulated with change in pigmentation level.

When chemicals were used to change the levels of pigmentation of melanocytes, the researchers found that along with changes in melanin levels, other signalling modules were also changing. Similarly, melanin level reduced when pigmentation decreased. A surprising finding was that when pigmentation was decreasing, the calcium signalling pathway was also decreasing. "We got a hint that the STIM1 protein, which is a key regulator of calcium signalling pathway, would be regulating pigmentation too," says Jyoti Tanwar from IGIB and one of the authors of the paper published in The EMBO Journal.

Zebrafish embryos

To confirm the role of STIM1 protein in pigmentation, the researchers knocked down the protein in melanocytes. This resulted in a reduction in pigmentation levels. "We further validated the role of STIM1 in regulating pigmentation in zebrafish models," Dr. Motiani says. "The knockdown of STIM1 significantly decreased pigmentation in zebrafish embryos. Both in vitro and zebrafish studies established the critical role of STIM1 protein in pigmentation."

The protein mediates calcium entry into cells and this leads to melanoma growth. "So calcium entry into cells



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

can be an attractive chemotherapy target for melanoma,” says Dr. Motiani.

“We will next be studying biopsy samples of human pigmented disorders. Our research has led to identification of a novel molecular target with high translational value,” says Tanwar.

‘We use a Trojan horse to deliver the drug’

One of the problems with medicine today is that good drugs often distribute equally into diseased and healthy cells. When drugs accumulate in healthy cells they often cause toxicity.

We have identified specific receptors or markers on cancer cells and other diseased cells [that are overexpressed] which distinguish them from healthy cells. We use these markers to deliver the drug specifically to the diseased cell, thereby avoiding the collateral toxicity to the healthy cells. Our technology is based on two simple principles: find a molecule that will home in on the diseased cell and then link that to a very effective drug that will treat the disease. So the drug piggy-backs on the homing molecule and accumulates in the diseased cell and not in the healthy cell. Sometimes we take advantage of the fact, for example, that cancer cells have an enormous appetite for folic acid — which is the Trojan horse that delivers the drug. They need a lot of this vitamin to divide; it is needed for DNA synthesis.

We can deliver a fluorescent dye to cancer cells using this method. This turns out to be very important because nearly 40% of all cancers tend to recur after surgery as the surgeon has failed to remove all of the malignant tissue. If we can help the surgeon see the residual malignant tissue, we can save a lot of lives.

Are there diseases that cannot be tackled with your method?

Theoretically, probably not. But we’re having a tough time getting our drugs across the blood-brain barrier. For that reason, we have not been able to treat the central nervous system diseases, such as Alzheimer’s, Parkinson’s... However, we have been able to treat brain cancers — when there is a cancer in the brain, it breaks down the blood-brain barrier, so you can get the drugs in.

What are the side effects of your method?

Side effects can arise from two problems. One is that we inject these, they circulate and gradually accumulate at the site of the tumour or rheumatoid arthritis or Crohn’s disease, whatever it is. If you don’t make the bridge — the link between the targeting molecule and the thera-

peutic warhead — stable enough, it can break before it reaches the diseased tissue. If that happens then you just release a free drug — no better than a non-targeted drug. And we do see that sometimes. These are things you can’t always predict from animal studies.

Second, nature did not design receptors to be only on cancer cells. The receptors we target are also invariably expressed in normal cells. We try to find receptors whose expression in normal cells is greatly reduced. We don’t go after receptors that are present even in 10% of the abundance they are on a cancer or some other disease tissue. This gives us a window and reduces the toxicity.

Vitamin C improves efficacy of TB drugs

Adding vitamin C as a nutritional supplement while treating drug-sensitive tuberculosis patients with first-line TB drugs will boost the efficiency of treatment, a study by Indian researcher’s shows. The increase in efficiency is not because vitamin C has antibacterial activity, as was suggested by a few researchers in 2013 from in vitro studies, but by doing the complete opposite — inducing dormancy in TB bacteria.

A team led by Prof. Jaya Sivaswami Tyagi from the Department of Biotechnology at AIIMS, New Delhi had first proposed the dormancy-inducing ability of vitamin C in TB bacilli in 2010 and has now reconfirmed it in a comprehensive study published in the journal Redox Biology. The team found that vitamin C imposes multiple stresses on TB bacteria such as hypoxia, acid stress (where the pH is reduced to around 5.5), oxidative stress (through the generation of H₂O₂ and reactive oxygen species), reductive stress (due to cessation of aerobic respiration) and metabolic stress. “As a result of these stresses, there is slowing down of metabolism leading to dormancy and further progression to viable but non-culturable (VBNC) state,” says Prof. Tyagi. “Together, these stresses remarkably resemble the host environment that the bacteria would face.”

In the lab, TB bacteria already exposed to vitamin C displayed resistance to two first-line drugs — isoniazid and rifampicin — as it progressed to a dormant state. Unlike these two drugs, pyrazinamide drug is capable of killing TB bacteria even in a dormant state. “The addition of vitamin C increased the population of dormant bacteria and this led to an eight-fold increase in pyrazinamide’s ability to kill the bacteria. There was also a fourfold decrease in the minimum concentration (MIC) of pyrazinamide required to kill the bacteria even in an infection model,” says Dr. Kriti Sikri from the Department of Biotechnology,



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

AIIMS and first author of the paper.

In the presence of pyrazinamide alone nearly 90% of the bacteria survived but when combined with vitamin C, the survival rate in vitro dropped sharply to less than 3%. "Vitamin C induces dormancy and enhances the population of slowly growing bacteria or bacteria that are not growing. And pyrazinamide drug targets these bacteria bringing about sharp reduction in the survival rate," explains Prof. Tyagi. "The effect of vitamin C combined with TB drugs was reproduced in an intracellular model, which is akin to human infection. So, our findings acquire clinical relevance. When used along with other first-line drugs, vitamin C has the potential to shorten the treatment time."

Screening novel drugs

Besides improving the efficacy of existing TB regimen, vitamin C can help in producing subclasses of bacteria to test new drugs. For instance, due to hypoxia, the metabolism gets slowed down leading to reductive stress. Lipids are formed as a compensatory mechanism and the breakdown of lipids produces energy. The AIIMS team used novel inhibitors to prevent the breakdown of lipids for energy purpose and this led to the death of TB bacteria.

Similarly, dormancy can be induced by adding vitamin C. Dormant bacteria are able to reduce the effectiveness of isoniazid and rifampicin by pumping them out using efflux pumps. The use of vitamin C can help in producing a population of dormant bacteria which can be used for screening drugs that inhibit efflux pumps, which the researchers were able to do. "We were able to reverse the tolerance and restore the bacterial sensitivity to these drugs by treating the bacteria with either of two efflux pump inhibitors — verapamil and piperine," Prof. Tyagi says.

Likewise, vitamin C can be used for producing viable but non-culturable (VBNC) TB bacteria. Though VBNC bacteria are present in sputum samples they cannot be cultured and hence never identified leading to misdiagnosis. The VBNC bacteria can always reverse and cause disease. "Unlike reports that 100 days are required to produce VBNC bacteria, our model can generate them in just eight days, which can be used for screening drugs," Prof. Tyagi says.

A novel platform to test drug sensitivity in bacteria

A two-member team from the Indian Institute of Technology (IIT) Delhi has used a novel method to culture bacteria and determine its growth at much lower concentration in relatively less time — four–six hours. *E. coli* and *S. aureus* bacteria were studied. Currently available clinical

methods require more than 10 hours to culture and observe growth of pathogenic bacteria and a higher bacterial concentration for laboratory confirmation.

While the new method will not be useful in identifying the species of bacteria isolated from a patient sample, it will help in early detection of the presence of bacteria and carrying out drug susceptibility testing within a short time period.

The team led by Dr. Neetu Singh from the Centre for Biomedical Engineering at IIT Delhi prepared alginate microgels that encapsulate *E. coli* bacteria and carbon dots. The microgel was prepared using sodium alginate solution to which the bacteria and carbon dots were added. Micron-sized droplets of the solution were produced using static electricity and dropped into a solution of calcium chloride for crosslinking.

The carbon dots used are pH sensitive. They emit light of two different wavelengths (450 nm and 550 nm) but the intensity of only one wavelength (550 nm) changes in response to a change in the pH. Measuring the ratio of the intensity of emission of light at two different wavelengths helps in detecting any change in the pH.

The microgels were found to support bacterial growth and colony formation, and the pH changes in response to bacterial growth. Generally, the pH becomes acidic when bacteria grow and multiply. But in some cases, the pH could become alkaline (basic) too. "The change in the pH, either acidic or basic, in response to bacterial growth can be detected by the change in the emission ratio of the two wavelengths," says Dr. Singh.

Unconventional

Unlike conventional methods that require 10⁵ CFU (colony forming units) and typically use 10⁷ CFU for detecting bacterial growth and take about 10 hours, the microgels needed only 10⁴ CFU. "A change in the pH was seen in about four–six hours when 10⁴ CFU were used and about eight hours when 10³ CFU were used," says Anil Chandra from the Centre for Biomedical Engineering at IIT Delhi and first author of a paper published in the journal *Chemical Communications*.

The team used the platform to test for antibiotic sensitivity by treating *E. coli* with ampicillin drug of different concentrations. "The microgel is porous and drugs could easily diffuse through the microgel," says Dr. Singh.

While the drug-sensitive *E. coli* showed less growth and produced only 5% change in fluorescence emission when ampicillin was added, the drug-resistant bacteria exhibited as high 35% change in emission. "This suggests that the bacteria were growing even in the presence of ampicillin and hence were drug-resistant," says Chandra.

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aspirantforum.com

Science and Tech.

The Crux of The Hindu

Vol. 13

News of Jan-Mar18

“Our platform will help in simultaneously studying resistance to different drugs, combination of drugs and resistance to different concentrations of drugs,” says Dr. Singh. “But it cannot be used when the drug has a buffering effect or when it is acidic, as the drug itself will change the pH of the microgel.” The team will be collaborating to develop a portable device with multiple functionalities and be testing clinical samples soon.

Artificial small intestine to study food, drug absorption

Scientists from Central Food Technological Research Institute (CSIR-CFTRI), Mysuru, and Indian Institute of Food Processing Technology (IIFPT), Thanjavur, have developed an artificial small intestine system to test the level of absorption of micronutrients and other bioactive compounds from food. While the artificial system requires just two hours to analyse the intestinal absorption, the methods currently in use are time-consuming and not suitable for studying large number of compounds.

The Netherlands Organisation for Applied Scientific Research has also developed an artificial system. “Unlike their system, ours simulates the exact physiological conditions and helps to evaluate both bioaccessibility and bioavailability of nanoformulated bioactive compounds,” says Dr. C. Anandharamakrishnan, Director of IIFPT and corresponding author of the paper published in the Journal of Food Engineering. It cost Rs 20 lakh to develop the system. The system consists of a perfusion chamber fitted with rat intestine. “To perform animal trials, we need at least 6–10 rats, but using this system just two–three rats would suffice,” explains DrParthasarathi Subramanian from CFTRI and first author of the paper. “There are severe ethical issues and infrastructure requirements that restrict the researchers in carrying out in vivo studies. To overcome this, the artificial small intestinal system was fabricated.”

The researchers checked the permeability of both fat-soluble (vitamin E) and water-soluble (gallic acid) compounds using the new set-up. “Bioactive compounds can use different mechanisms for crossing the intestine. Fat-soluble compounds follow transcellular absorption whereas paracellular route of absorption is used by water-soluble compounds. So we tested both compounds,” says Dr. Anandharamakrishnan. The researchers then compared the performance of the set-up to in situ intestinal perfusion study. For the perfusion study, the rat was anaesthetised and the absorption of both compounds were studied.

Relative performance

In the case of the fat-soluble compound, the permeability was higher in rats than the new system. But the artificial system performed better for the water-soluble compound. “The absorption of the fat-soluble compound is facilitated by carrier proteins like NPC1L1 in the intestinal cells. But in the engineered system, there is no carrier-mediated uptake, only passive diffusion. So the engineered model is best for studying compounds with passive diffusion” adds Dr. Anandharamakrishnan. A patent has been filed and the system is currently in use at IIFPT.

Where insects play games to advance science

At Shannon Olsson’s lab at National Centre for Biological Sciences (NCBS), Bengaluru, the emphasis is to get into the mind of insects to study how they perceive various stimuli even though they have brains the size of pin-heads. And one way they plan to do this is by building up a virtual reality system that is guided by the study subjects – the insects themselves!

The insect being studied, in this case the apple fly, is tethered to a holder by means of a very fine string so that it cannot move away. The only thing it can do is flutter its wings and “tend” to move in some direction. This insect is placed at the centre of a semi-circular assembly of monitors on which a landscape is shown. The virtual landscape may contain a meadow, trees with various fruit on them, the sky, shrubs etc. In addition, through tiny perforations, wind can be blown on the fly to simulate the breeze. This may come mixed with various volatiles (smells) of fruit, grass etc.

Two cameras observe the reactions of the insect and feed this into the computer that discerns the trajectory, or intended direction of motion, of the insect. Accordingly, the computer adjusts the landscape shown on the monitors. So that if the fly tries to move towards a tree, that portion zooms and the rest shrink, so that it appears to the fly as if it has gone close to the tree. It reacts to this and the cameras feed this back into the computer which once again adjusts the landscape and so it goes.

Using virtual reality to study insects is itself not exactly new: “While true VR for insects does not yet exist, scientists have been tethering (restraining in place) flying insects to study their flight behaviour in front of moving displays for nearly 50 years,” says Shannon Olsson.

How does the fly see?

The question the researchers are trying to understand by building this experiment is – how can an insect differenti-



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

ate between various stimuli it sees, hears and smells? For instance, what makes the insect drift towards a particular flower or fruit? “Since it is impossible to know when and how an animal receives these cues in the real world, we are creating a virtual world where we can know precisely when the animal receives the colour, shape or smell of a virtual object, and observe its behaviour at that moment as well,” she adds.

This system was built and calibrated over the past two years by Pavan Kumar Kaushik of NCBS for his dissertation work. The graphical interface was built in Germany and inputs for the design came from collaborators in the U.K. “Calibration was performed by directly testing the insect itself. The success of this instrument lies in our chosen system — nearly 50 years of research on the behaviour and ecology of the apple fly have provided us with a large body of knowledge about how they behave in the natural world,” says Pavan Kumar Kaushik. “Our benchmark is therefore how well we can replicate those behaviours in our arena. Essentially, if they respond to virtual objects and a virtual world the way they do in apple orchards, then we have calibrated our parameters properly.”

The team aims to unravel how insects find their food and what stimulates their movements. “Ultimately, we will explore the locations in the brain where this information is being processed, which we have been pursuing with other projects in the lab that measure the neural activity of insect brains,” says Dr Olsson.

More efficient desalination with crystalline carbon dots

Researchers at Indian Institute of Technology (IIT) Guwahati have been able to synthesise highly crystalline carbon dots by doping them with nitrogen, sulphur and phosphorus. The amount of phosphorus defined the extent of crystallinity. Unlike an amorphous material, less light was scattered or reflected from crystalline carbon dots on shining light. Instead, the crystalline material efficiently converted the absorbed light energy into heat energy.

Simulated sunlight

The team led by Prof. Arun Chattopadhyay from the Department of Chemistry successfully used the crystalline carbon dots for desalinating seawater by exposing the carbon dots to simulated solar conditions. “The doped carbon dots were not only able to convert light into heat energy but were also able to interact with water and transfer the heat energy to water thus raising its temperature,” says Prof. Chattopadhyay.

Compared with carbon dots that were doped with all the three elements, those doped with only nitrogen and sulphur were amorphous in nature. “When only nitrogen and sulphur are present the polycyclic carbon does not arrange in a particular manner, making it amorphous. But phosphate esters that form when phosphoric acid is added bond the polycyclic fragments. That is what makes it crystalline,” says Dr. GayatriNatu from the Department of Chemistry, IIT Guwahati and a coauthor of a paper published in Journal of Materials Chemistry A.

The three- and two-element carbon dots added to water (with concentration up to 250 mg per millilitre) and exposed to simulated sunlight under reduced pressure showed wide variability in their ability to transfer heat energy to water.

There was 43.5% evaporation of water within 15 minutes in the case of carbon dots doped with three elements and only 38.3% with carbon dots doped with only nitrogen and sulphur. “When we calculated the solar thermal evaporation efficiencies under standard atmospheric pressure, carbon dots doped with three elements had nearly 84% efficiency. It was about 44% with carbon dots doped with only nitrogen and sulphur,” Prof. Chattopadhyay says.

Thorough testing

The team tested the ability of the doped carbon dots to desalinate seawater samples from Bay of Bengal, Persian Gulf and a sample with average sea water salinity. Maximum desalination was achieved with carbon dots doped with three elements in the Bay of Bengal water sample — 43% evaporation of the initial volume in 15 minutes. Only 35.5% seawater evaporated during the same time in the case of carbon dots with two elements. They tested the doped carbon dots’ ability to desalinate seawater even when the salt concentration was in excess. To do this, more seawater was added to the residual seawater after each cycle and the desalination efficiency was tested for nine cycles.

“The doped carbon dots with nitrogen, sulphur and phosphorus elements retained up to 78% of the original desalination efficiency even at the end of the ninth cycle,” says Ayan Pal from the Department of Chemistry, IIT Guwahati and first author of the paper. “The doped carbon dots can be reused by removing excess salt through dialysis.” Recalling how they stumbled upon doped carbon dots for desalination, Prof. Chattopadhyay says: “We have been working with doped carbon dots and investigating their properties. We found that one set of doped carbon dots was highly crystalline. Since we were interested in the production of hydrogen from water using sunlight we



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

tested these crystalline carbon dots. Though it didn't produce hydrogen gas, it was evaporating water quickly. So we started testing it for desalination."

"We are now trying to make doped carbon dots that are super crystalline so that energy is even more efficiently converted into heat. We also trying to make a film or sponge-like device that floats on water and evaporates water by converting sunlight into heat," Prof. Chattopadhyay says.

Mitochondria: Immigrants that add power to the mother's cells

Immigration is much in the news these days. But, go back to history, and we find that early humans started migrating 'Out of Africa' since about 3 million years ago. As territories, communities and nations became established, movement from a 'foreign' place or group into such 'nations' became the basis of accepting or denying entry. This depended on whether the migrants added 'value' to the locals or otherwise.

In biology, this process has been on even at the single-cellular levels, over 2.5 to 3 billion years ago — and continues even today. Leave alone infection by pathogens; there have been helpful ones too. Two outstanding examples of helpful immigration that happened during those early years are chloroplasts and mitochondria. The chloroplasts are neatly packaged mini-cells which come with their own genetic make-up, and they have the ability to absorb sunlight and use it to convert atmospheric carbon dioxide and water to produce the sugar glucose and the gas oxygen. They appear to have arisen from even more ancient cells called 'cyanobacteria' (3.5 billion years ago), and have migrated from there to plant cells. This immigration led to what is called the 'oxygen revolution', through which the air surrounding the earth became over 20% rich in oxygen (pranavayu - a gas without which we cannot live).

Powerhouses and solar panels

At about the same time, or a bit later, another ancient life form, derived from 'the purple bacterium', migrated to both plant and animal cells. This is the mitochondrion. Mitochondria do the reverse; they use oxygen and enhance the metabolic energy production of their 'host' cells by as much as tenfold. (For example, when you exercise rapidly and are short of breath, each molecule of glucose in your cells generates three molecules of lactic acid, and produce three units of energy in the process. But when you now take a deep breath and inhale oxygen, the immigrant mitochondria in your body cells break down the accumulated lactic acid to produce carbon dioxide, wa-

ter and 30 units of energy). Mitochondria are thus powerhouses in cells, as chloroplasts are solar panels of energy in plants.

Cellular immigrants such as these two are welcome in cells and have been given permanent residence permits therein. But they bring their own genomes through which they produce progeny, and live in ghettos called organelles in the cells, offering power and prosperity to their hosts. All animals, plants and fungi have accommodated mitochondria in their cells. The number of mitochondria in a cell varies depending on the role of the cell. Muscle cells, which have high energy, needs have large numbers of mitochondria in them, while red blood cells whose job is just to transport oxygen have none.

Given all this importance of mitochondria, it comes as a surprise to learn that we humans inherit our mitochondria only from the mother and none at all from the father. In other words, it is the mother who provides her progeny the Power-Pack that her children's body cells need. So it is in plants too; it is the female that provides the chloroplasts. This too is a process that has been conserved evolutionarily from worms, fruit flies, animals and humans, and is referred to as 'uniparental inheritance'.

But how and why does this happen? After all the egg cell is fertilized by the sperm cell, and both of them carry their own mitochondria. And as the sperm cell enters the egg cell, its mitochondria are eliminated, and why? This is a puzzle that has bothered scientists, and several suggestions have come about recently. Some have proposed that mitochondrial DNA is inherently more prone to damage than nuclear DNA, and that if the introduced mitochondria are avoided or deleted, one can make do with the maternal mitochondria, which can be multiplied as the embryo forms and develops. Dr. William Bridg of Ohio State University, USA, who has long studied this problem, suggests that such uniparental inheritance of mitochondria (and chloroplasts too) reduces the spread of parasites that lurk around in the cytoplasm, and also errors through what is termed as 'selfish' DNA (keep on making more copies of its segments, see his review in PNAS 92, 11331-38, 1995). Likewise, Dr. J.M. Cummins of Murdoch University in Australia suggests that doing away with the mitochondrial DNA contained in the sperm helps in preventing the inheritance of damaged or mutated DNA, occurring due to free-radical based damage (Hum. Reprod. 2000; July 15, Suppl. 2:92-101). And the review by Greiner et al. (Bioessays 2015. 37(1) p.80-94) posits that such removal of sperm-based DNA helps in avoiding competition between organelles, and also in avoiding negative interactions between the organelle and

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

nuclear genomes).

The most recent paper by Dr. Ding Xue of the University of Colorado, USA and colleagues (Science 2016 July 22; 353 (6297) p.394-399) uses the transparent worm *C. elegans* and shows that the paternal mitochondria rapidly lose their inner membrane when entering the egg cell, releasing an enzyme that chops up the DNA therein, and which also aids in the maternal garbage disposal (called autophagy and proteasome) machinery. The last word is not said yet, but it does appear that the mother cell decides that it is best to make do with what it has, and not seek the aid of damage-prone external mitochondria for the job ahead. Mother knows best!

IGIB researchers partially reverse a rare disorder

Researchers at Delhi's Institute of Genomics & Integrative Biology (CSIR-IGIB) have for the first time used zebra fish to model the rare genetic disorder — Rubinstein Taybi Syndrome (RSTS) — seen in humans. They have also used two small molecules to partially reverse some of the defects caused by the disorder in zebrafish, thus showing them to be an ideal animal model for screening drug candidates. There is currently no cure or treatment for the disorder.

The Rubinstein Taybi Syndrome has a frequency of about one in one lakh people, and causes intellectual disability, growth retardation (short stature), craniofacial deformities, heart defects and broad thumbs and toes. The results were published in the journal *Biochimica et Biophysica Acta (BBA) - Molecular Basis of Disease*.

Close to human genome

Since zebrafish genome has very close similarity to human genome and the embryonic developmental is very similar in the two, the team led by Dr. Chetana Sachidanandan at IGIB went about checking if EP300, one of the two genes that cause the disorder is present in the fish and if mutations in this gene result in a RSTS-like disease in fish.

Using chemicals, the researchers inhibited the activity of the protein Ep300 to see if this resulted in the manifestation of the disorder in the brain, heart, face and pectoral fins (equivalent to forearm in humans). "Like in the case of humans, the same organs were affected in the fish when the functioning of the protein was stopped. This helped in confirming that the protein in question does the same functions in fish and humans," she says.

Since zebrafish commonly has two copies of many human genes, the researchers first checked if one or both

the genes were functional and equivalent to the human gene that causes the disorder. "We found Ep300a gene was active and functional while Ep300b was not," says Prof. Tapas K. Kundu from the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru, the other corresponding author. The Ep300a gene is responsible for producing a protein (Ep300) that opens up the DNA.

"The protein Ep300 is evolutionarily conserved from fish to humans. Though the Ep300 gene has been earlier identified in fish, its function was not known," says Prof. Kundu.

Reversal of effects

Like in the case of fish treated with chemicals manifesting the disorder, fish mutants that lacked the Ep300a gene too exhibited defects very similar to those seen in humans.

"When we introduced excess amount of a tiny portion of the Ep300a protein in the mutants, the craniofacial deformities became less severe [mutants had severed craniofacial deformities] and pectoral fins in the fish became normal," she says.

But neuronal defects were not reversed, even partially. "It might be because only a portion of the protein was put into the fish. Probably, that portion isn't sufficient to compensate for the loss of the whole protein," she explains.

"It's proof-of-concept that just a piece of the protein is sufficient to reverse some defects, even if only partially, in zebrafish," Dr. Sachidanandan says.

Alternatively, the researchers used two small molecules to reverse the defects. If the protein Ep300 is responsible for opening the DNA, there are other proteins that are responsible for closing the DNA.

The two molecules were found from a screen of compounds well known for their ability to inhibit proteins responsible for closing the DNA.

Like in the case when excess amount of Ep300 protein was introduced, both the molecules could partially restore facial defects but not the neuronal defects.

"Introducing excess amount of a portion of the ep300 protein showed greater rescue of deformities than the small molecules," says Aswini Babu from IGIB and first author of the paper. "But rescuing the deformities using small molecules is a relatively easier and better option."

Taking a walk in the fruit fly's shoes

The humble fruit fly which has helped humans win five Nobel prizes has now revealed to scientists how we walk and the brain cells that control this mundane activity.



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

Researchers working at the National Centre for Biological Sciences, Bengaluru, investigated the role of interneurons in walking. Interneurons generate the rhythmic pattern and control the leg motor neuron activity. The fruit fly (*Drosophila melanogaster*) was used to investigate the mechanism underlying elementary walking behaviour owing to their simpler neural circuitry, shorter life cycle and ease of study.

“The insect’s nervous system (ventral nerve cord) is comparable to that of a human’s spinal cord and comprises a group of motor neurons, interneurons and sensory neurons, which respond to the outside world,” says Swetha B.M. Gowda, a Phd student from Manipal Academy of Higher Education, and lead author of the paper in an e-mail to The Hindu. “While there is a good understanding of motor neuron structure and their connections to leg muscles, the role of interneurons in the regulation of walking is not explored.”

The researchers examined the role of a gene called Rdl that responds to a neurotransmitter called GABA and inhibits the activity of the motor neurons. They observed that lowered levels of Rdl in leg motor neurons alter normal walking in terms of speed and step length. The results were recently published in Proceedings of the National Academy of Sciences.

High-speed video recordings were then employed to monitor the individual leg movements of a freely walking fly. “We developed a computer program that automatically follows the legs of a walking fly and measures various aspects of walking such as coordination, step-length, speed etc,” says PushkarParanjpe, co-author on the paper.

The study also emphasizes the role of the ventral nerve cord (similar to the spinal cord) in normal walking and excludes any participation from the central brain. They observed that defects in the ventral nerve cord can lead to problems in different aspects of walking.

“The molecules that govern the development and behaviour of a fruit fly are remarkably similar to the molecules important for normal human development and behaviour. Therefore, the pharmacological agents that are used to treat human neurological disorders can be studied in a fruit fly disease model.” says SudhirPalliyil, also a co-author of the paper in an e-mail to The Hindu.

“The fly’s ventral nerve cord receives signals from the outside world and also from its brain. Its output is to control the muscles which result in movement. In this general sense, it is very similar to the spinal cord,” says K. VijayRaghavan, the principal investigator of the group and

corresponding author of the paper.

“Without brain input, coordinated walking can still take place in flies and in vertebrates too. But, visual inputs and other higher-level controls will of course be absent. As the ventral cord both receives signals (as above) and sends outputs; defects anywhere in this path can affect locomotion. The specific neuron where these defects are present, and when so, result in walking defects is what we seek to find. That can tell us both how and why defects can occur and how to fix them.” he explains in an e-mail

Silver silk patch aids healing of wounds, prevents infection

By embedding silver oxide nanoparticles on silk fibre, scientists have produced a new material that can be used to make patches to help in healing of wounds and in preventing infection. The patch was able to heal scratch wounds completely in 24 hours and also kill pathogens like *S. aureus* and *M.tuberculosis*.

The researchers first tested the mechanical properties of the silk patch. “An ideal wound-dressing material should have good thermal insulation and also allow gaseous and fluid exchange in the wound area. The new material was able to maintain the moisture and had ideal water-holding capacity,” says DrPunuriJayasekharBabu, post-doctoral researcher, IIT Madras, and the first author of the paper published in Colloid and Interface Science.

“We also performed experiments to find the swelling and degradation properties of the silk patch, which are important for wound healing materials. The patch was hydrophilic in nature and its morphology did not change [that is to say] it did not degrade even after 14 days of immersion in phosphate buffer solution (PBS),” he adds. Phosphate buffer solution has a pH of 7.4 which is close to that of human cells.

Anti-bacterial activity of the patch against non-pathogenic *E.coli* and two pathogens *S. aureus* and *M.tuberculosis* was tested. The silk patch was found to be more effective than the commercially used antibiotic, ciprofloxacin.

The exact mechanism behind antimicrobial activity is unknown. Some studies have reported that silver creates ‘pores’ on bacterial cell walls, thereby causing their death.

Wound healing

In vitro wound healing (scratch assay/cell migration) study revealed faster migration of 3T3 Swiss mouse fibroblast (cells responsible for wound healing) cells to the wound area treated with the silk patch. The wound was completely covered in 24 h.



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

Cytotoxicity studies also showed that the silk patch was not harmful to the cell lines.

Cells treated with silver alone and silk alone did not show such good wound-healing properties. "We will test the synergistic wound-healing and antibacterial activities of this silk patch on animal models and then this can be commercialised for clinical use" says Prof. Mukesh Doble, Professor at the Department of Biotechnology, IIT Madras and corresponding author of the paper.

IIT Delhi researchers develop scar-tissue model for screening drugs

Researchers at the Indian Institute of Technology (IIT) Delhi have for the first time developed a 3D scar-tissue model through tissue engineering. The two-member team led by Prof. Sourabh Ghosh from the Department of Textile Technology at IIT Delhi was successful in replicating the early inflammatory microenvironment that initiates a cascade of events that lead to scar development.

Drugs currently available to reduce scarring in the case of deep wounds that affect all the layers of the skin have limitations owing to poor understanding of scar tissue formation and the signalling pathways responsible for its development. This is particularly so as results of scar tissue models created in animals have limitations when extrapolated to humans. Also, the European Union directive to find alternatives to animals testing makes Prof. Ghosh's relatively simple in vitro scar-tissue model ideal for drug testing.

Optimised cocktail

The researchers first encapsulated fibroblasts from healthy human skin within the collagen gel. Three days after an optimised cocktail of three cytokines were added to the media, differentiation of dermal fibroblasts into myofibroblasts was triggered. Myofibroblasts are bigger in size than fibroblasts and have greater contractile power, something that is essential to close the wound. Scar-specific proteins are expressed by myofibroblasts.

"There was an increase in the scar-specific proteins and gene expression with increasing duration of culture. By day 14, scar-tissue similar to what formed naturally on human skin was formed," says Shikha Chawla from the Department of Textile Technology at IIT Delhi and first author of a paper published in the journal *Acta Biomaterialia*.

Typical features

In addition to the differentiation of fibroblasts into myofibroblasts, the researchers witnessed other typical features that cause scar formation. For instance, during the wound-healing process, excessive fibrous extracellular

matrix is produced.

While there is excessive production of extracellular matrix proteins, the secretion of matrix metalloproteinase, whose role is to degrade certain proteins such as ECM, is reduced. As a result, the tightly regulated balance between synthesis and degradation of matrix components get disturbed, and the skin gets thicker and stiffer. There was also increased expression of alpha smooth muscle actin, a cytoskeleton protein, in the in vitro scar model. "The alpha smooth muscle actin is a characteristic marker of myofibroblasts. The cytoskeleton protein is expressed as a thick bundle that stretches the cell thereby causing contraction," says Chawla.

"All these features that make the scar tissue thicker and stiffer in humans are already known. Using tissue engineering strategies, we are now able to replicate these features in the in vitro 3D model," says Prof. Ghosh.

"In addition to these five features, the scar model was also able to replicate two important cellular signalling pathways through which scar tissue are formed," says Prof. Ghosh. "Since the scar tissue formed in vitro followed similar signalling pathways as natural scar tissue, new drug molecules and immunomodulatory strategies designed to manipulate one or both the pathways might help in modulating scar tissue formation."

Implications

Creating scar tissue in the lab has great implications for the pharmaceutical industry. "The cosmetic and pharmaceutical industries, which are developing anti-fibrosis or anti-scar medicines, need not have to test them on animals. They can use our tissue-engineered model instead," he says.

The team is now using selective peptide domains and a 3D bioprinting strategy to develop progressively more complex in vitro scar tissue, which would recapitulate more hallmark features that are critical for tissue fibrosis.

IIT Bombay fabricates wearable sensor for monitoring movement

A team led by researchers from the Indian Institute of Technology (IIT) Bombay has developed an inexpensive, flexible pressure sensor that can be used for a variety of health-care applications. The piezoresistive pressure sensor could efficiently monitor even small-scale movements caused by low-pressure variations.

Pulse rate

The sensor could measure blood pulse rate in real time when placed on the wrist and neck. It had the same sensitivity and accuracy at both sites of the body. The sensor



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

was also tested for its ability to monitor respiration. When placed on the throat, the sensor could detect changes in pressure when different words were pronounced. Interestingly, the fabricated sensor also showed good sensitivity in detecting large-scale motion monitoring, as in the case of bending and extension of fingers joints. The results were published in the journal ACS Applied Materials and Interfaces.

"While researchers have been working to develop sensors that can detect very small change in pressure, our pressure sensor is able to detect both small-scale motion caused by low pressure (less than 2.7 kPa) and large-scale motion at high pressure," says Amit Tewari at IITB-Monash Research Academy, IIT Bombay and first author of the paper. "The sensor exhibited good flexibility and reproducibility over 5,000 cycles."

"When you speak, the throat muscles respond differently based on the change in pressure. The vocal muscles undergo different motions when different words are pronounced. The sensor was able to detect the slight change in pressure when different words were said," says Prof. Dipti Gupta from the Department of Materials Science and Engineering from IIT Bombay, who collaborated with researchers from Cambridge and Monash University, Australia.

Word recognition

The researchers tested its sensitivity in recording the difference in pressure when different words were said, and when the same word was repeated several times. "The sensor can be used as a word-recognition device. This is only preliminary work and more has to be studied before the sensor can be used for speech recognition," says Prof. Gupta.

The device was also able to detect the pulse rate. "It is a proof-of-concept study and more work needs to be done. We are yet to calibrate the sensor," she says. Since the sensor was able to detect differences in blood pulses, Prof. Gupta feels it can be used as a wearable sensor for long-term and continuous monitoring of heart rate.

In the case of finger bending and extension, which involves monitoring the large-scale motion, the sensor showed high sensitivity. The sensor generated different current signals when the index finger, to which it was attached, was bent. The current signal was the least when the angle of bending was small (15 degree) and maximum when the angle was high (90 degree).

"We have not tested the change in pressure due to change in direction of movement of the finger," she clarifies.

The sensor is made using polyurethane foam coated with

carbon nanomaterial-based ink. The ink is conductive due to the presence of large number of multiwalled nanotubes which are dispersed in reduced graphene oxide matrix. Conductive sheets were pasted on the top and bottom sides of the foam and electrical wires connected to the sheets for measurements.

"When the PU foam coated with the ink is perturbed, in this case compressed, the air gaps are removed and the foam gets thinner. This provides a conduction path for electrical charges. The resistance drops as the foam is compressed and it becomes more conductive," says Tewari.

Mobile nanotweezers can pick, drop live bacteria

A team from Indian Institute of Science, Bengaluru, has succeeded in designing a new class of mobile nanotweezers that can pick up, hold and move tiny cargo, the size of molecules, in a fluid. The work by Souvik Ghosh and Ambarish Ghosh of Centre for Nanoscience and Engineering, IISc, overcomes the earlier limitation of nanotweezers that were only able to trap and hold the molecules. Apart from nanoscale assembly – where tiny objects such as nanodiamonds or quantum dots need to be picked up and moved to a desired location — this has applications also in microfluidics, where live bacteria need to be manipulated and in biomedicine.

Limitations

Picking up and moving molecules suspended in a fluid, such as a colloid, is a busy area of research. Plasmonic nanotweezers — nanosized tweezers made of noble metals, which have been studied so far to trap cargo, have the limitation that they are fixed in position. When they are illuminated by light, they develop a 'potential gradient' around them. This is like a slope, and nearby particles gets attracted to the potential's minimum just as things roll down a slope. However, the limitation is that it can only capture particles that are within the range of the field.

In the new work, the robotic, mobile nanotweezer can pick up tiny particles and move them over a short distance when the microrobots are subjected to an external magnetic field. "We can tune our trapping and releasing mechanism by subsequently turning the incident illumination on and off. To move these nanotweezers, we use a rotating magnetic field which rotates the helix [of the nanotweezer] and [moves it] like a cork-screw," says Souvik Ghosh, first author of the study published in Science Robotics.

Thermal fluctuations

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

The colloidal particles move due to thermal fluctuations, therefore it is very difficult to manipulate the nanoparticles. Also as the size of the particles decreases, so, too, does the trapping force. The researchers' main challenge was to overcome this and generate sufficient trapping force using a small amount of laser power. To achieve this, small helical structures are grown on a pre-patterned substrate by electron beam evaporation of silicon dioxide (made of mostly glass). "The substrate is kept at an extreme angle to the incoming vapour flux and rotated slowly to achieve the helical shape. Apart from glass, we also combine silver (plasmonic properties) and iron (magnetic properties) nanostructures at appropriate places on the helical body," explains Souvik Ghosh, in an email to The Hindu.

As a next step, the team is working on parallelising the process. Thus, a series of microrobots will work together like an assembly line. "This will allow us to scale up our technology and will surely have commercial impact, and initial results are promising," says Mr Ghosh.

No sign of new neurons in adult humans, says study

The human brain may not be as pliant as was believed, a recent study shows. In this study, bound to provoke argument, researchers observe that the latest neurons form in the brain when the subject is about 13 years old and no later. This finding, published in Nature, contradicts earlier experiments, according to which neurons in the hippocampal region of the brain could be formed even late in adulthood.

Hippocampus

The hippocampus is a region which is believed to be the abode of long-term memory and emotional responses. This was also believed to be true in other mammals such as chimpanzees and rodents.

In the study, the researchers took advantage of the fact that specific antibodies could bind to proteins of interest and indicate their locations in tissue. They thereby identified the locations of the neural precursor cells, proliferating cells and immature neurons in samples from 59 human subjects and traced the development from the foetal stage to old age. Up to 14 weeks of gestation, the three cell types migrated from their point of genesis to the region within the hippocampus – the dentate gyrus – where they stayed and developed. The oldest individual they observed with immature neurons was 13 years old.

The researchers observe that a lack of neurogenesis in the hippocampal region has been suggested in the case of some aquatic mammals like dolphins, porpoises and

whales. This is interesting because these mammals are known for their intelligence, longevity and complex behaviour, too. They also offer a reason for why humans appear to differ so drastically from other mammals studied.

IIT Guwahati develops super hydrophobic coating that mimics lotus leaves or rose petals

A polymeric coating that is extremely water-repelling (superhydrophobic) and will allow water to roll off from the surface like in the case of a lotus leaf or stick to the surface as in the case of rose petals has been synthesised by a two-member team from the Indian Institute of Technology (IIT) Guwahati.

It can be spray-coated on various surfaces (glass, plastic, metal, wood and concrete) of diverse chemical composition, texture (smooth or rough surface), geometry (plain sheet or complex shape such as shoes), and size. The researchers led by Dr. Uttam Manna from the institute's Department of Chemistry found the water-repelling property of the coating remained intact even when subjected to severe physical and chemical abuse.

Modulated functionality

By modulating the functionality of the coating with small amine molecules, the coated surface was made to behave either as non-adhesive superhydrophobic coating (where water rolls off as in a lotus leaf) or adhesive superhydrophobic coating where the droplets stick to the surface like in the case of rose petals. The results were published in the Journal of Materials Chemistry A.

"There is a fundamental difference in the way the trapped air is present at the interface between the surface and water droplets and this makes the coated surface either adhesive or non-adhesive superhydrophobic," says Dr. Manna. In the case of the non-adhesive superhydrophobic coating, the trapped air is continuous and uniformly distributed. This leads to the trapped air minimising the contact area between the water droplet and the substrate. With adhesive superhydrophobic coating, the trapped air is not continuous and the contact area between the water droplet and the substrate is more thereby causing the droplets to stick to the surface up to 20 degrees tilt angle. The superhydrophobic coating was prepared by mixing a polymer (branched poly(ethyleneimine)) and a reactive small molecule (dipentaerythritol penta-acrylate) in different alcoholic solvents — ethanol to pentanol.

"We were able to achieve a stable coating only when pentanol solvent was used," says Dr. Manna. The polymer and the small molecule react rapidly in the presence of pentanol. Also, the volatility (rate of evaporation) of pen-

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

tanol is way less compared with other alcoholic solvents. "As pentanol evaporates slowly, it allows the reaction between the polymer and small molecule to be completed thus making the coating to be stable and uniform," says KoushikMaji from the Department of Chemistry at IIT Guwahati and first author of the paper. "With other solvents, the reaction is slower and the solvents evaporate quickly leading to less stable coating (cracking and peeling)."

The coating is highly chemically reactive and this makes it possible to post modify the coating with amines containing small molecules to make it either adhesive or non-adhesive superhydrophobic. Unlike in other cases, the reactants themselves get covalently cross-linked thus making the use of external binder or cross-linker for stability redundant.

The superhydrophobic coating has diverse applications depending on whether it is made adhesive or non-adhesive. The non-adhesive one can be used for oil-water separation and making the surface self-cleaning.

Since the coating remains adhesive up to 20 degrees of tilt, the adhesive coating can be used in open microfluidic devices for diagnostic purposes where controlled transfer of aqueous droplets without any loss in volume is needed.

Novel nanoparticles to help cell imaging

New fluorescent nanoparticles created from simple biomolecules can now help light up cancer cells for better imaging.

Scientists from Indian Association for the Cultivation of Sciences (IACS), Kolkata have created nanoparticles from folic acid, riboflavin and lactose and tuned the molecules to give a green fluorescence to help in cell imaging using bright-field microscopy.

"The cadmium selenium quantum dots currently used for imaging purposes are highly toxic to the human cells. But we have used simple molecules which are found within the human body as basic ingredients to do the same work," says Dr. Nikhil R Jana, Professor and corresponding author of the paper published in MRS Advances.

Green fluorescence

The newly created nanoparticles are mixed with the cell culture medium, kept for 2-3 hours, washed and then viewed under the microscope. The nanoparticles label the cancer cells alone and are seen with a green fluorescence under the microscope.

The nanoparticles exhibit specific labelling properties. Since oral cancer cells have folate and riboflavin receptors, the nanoparticles prepared from folic acid and ri-

boflavin bind to these receptors. Folic acid nanoparticles bind to ovary cancer cells, while nanoparticles made from lactose bind to galactose receptors found on liver cancer cells.

They found that the green fluorescence depended mainly on the temperature at which they were treated. "We used a wide range of temperature for cooking the molecules (90-340 degree C). The broadness of the fluorescence spectra increased with the lowering of the reaction temperature," says Hayder Ali, PhD scholar and first author of the paper. "These new nanoparticles are less than 10 nanometre in size and can also be used for targeted drug delivery as they seem to have specific labelling abilities." Preliminary in vivo studies using a mouse model show no toxicity, and the researchers are currently working on getting a red emission so that bioimaging can be done with low background signal.

Now, low viscosity fuel oil from plastic waste

Certain plastic wastes can soon help fuel your cars. Researchers from IIT Guwahati have successfully converted packaging plastic waste to plastic-derived oil (PDO), which has characteristics similar to diesel.

Low- and high-density polyethylene (LDPE, HDPE) and polypropylene are commonly used as packaging materials and end up in the waste stream. According to a 2016 Central Pollution Control Board report, almost 15,000 tonnes of plastics waste is generated per day in India.

The researchers collected the waste (biscuit wrappers, shopping bags, food containers, shampoo bottles) from houses, cleaned and segregated them according to the resin identification code. These codes on plastics indicate the type of plastic resin it is made of.

Using a semi-batch reactor, the different wastes were heated for six to seven hours at 300-400 degree Celsius. "Heating at very high temperatures in inert conditions caused the plastic to convert into wax, so we chose this particular temperature range in which the plastic turned to plastic-derived oil and stayed in its oil state," explains Pallab Das, PhD scholar at the institute and first author of the paper published in Resources, Conservation and Recycling.

But burning plastic waste generates pollution, particularly dioxins which are toxic to humans. "There is no oxygen in the three plastic wastes that is heated that we are also not supplying any oxygen. Pyrolysis is done under inert conditions. Only hydrocarbon gases such as methane, ethane and propane were produced and there was negligible amount of carbon dioxide and carbon monoxide

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

produced,” says Das.

Further research

“More experiments need to be carried out to get a trade-off between the quality of the oil and the environmental pollution caused by the pyrolysis process. We are working on this and hope to create an ideal operating condition which can provide high-quality oil with less pollution,” says Dr. Pankaj Tiwari, Assistant Professor, IIT Guwahati, and corresponding author of the paper. “Compared with combustion, pyrolysis causes less pollution.”

The researchers then studied the properties of the new plastic derived oil. One of the oil samples from polypropylene showed a high research octane number of approximately 92. Octane number indicates the quality of the gasoline range fuel. Premium petrol has research octane number of 98 to 100.

The oil also showed low viscosity and had high calorific value. Calorific value denotes the amount of heat generated when unit amount of sample was burnt with oxygen supply. The new oil had calorific value greater than 45 MJ per kilogram. Calorific value of petrol and diesel is 46-48 and 44-46 MJ per kilogram, respectively.

“We are yet to carry out engine tests. Once tested, these oils can soon find application in transport and industrial sectors,” says Dr. Tiwari.

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

COMPUTER & IT

Threat of new malware looms over cyberspace

A new threat looms large on the horizon of cyberspace. After Mirai and Reaper, cybersecurity agencies have detected a new malware called Saposhi, which is capable of taking over electronic devices and turning them into 'bots', which can then be used for any purpose, including a Distributed Denial of Service attack which, with enough firepower, can cripple entire industries.

Being monitored

A senior cyberpolice officer told The Hindu that Saposhi was detected around 15 days ago, and is currently being watched and studied.

"Saposhi is similar in its intensity to Reaper, which was taking over millions of devices at the rate of 10,000 devices per day. Various cybersecurity agencies are currently keeping tabs on it to get a better idea of what it is capable of," he said.

In October last year, the Computer Emergency Response Team (CERT), a Central government body that deals with cyberattacks, had issued an alert about Reaper, a highly evolved malware capable of not only hacking devices like Wi-Fi routers and security cameras, but also hiding its own presence in the bot — a device taken over by a malware.

Sources said that while the CERT has not yet issued any alert regarding Saposhi, guidelines for protecting devices from Saposhi are likely to be issued in the days to come.

"We need to first ensure that the information we have is indeed substantiated before raising alarm bells. Right now, what we know for sure is that Saposhi exists, and is highly capable. Factors like whether it is aimed at any particular kind of device, or has a specific purpose are still being verified," another officer said.

Malwares like Saposhi, Reaper and Mirai are primarily aimed at DDoS attacks, in which the malware first creates a network of bots — called a botnet — and then uses the botnet to ping a single server at the same time. As the numbers of pings are far beyond the server's capacity, the server crashes and denies service to its consumers. For example, if a large botnet attacks the server of a fleet cab provider, its server will crash, and scores of consumers will be unable to avail of its services, causing chaos in daily commuting as well as massive losses to

the company.

In July 2016, small and medium internet service providers in Maharashtra fell prey to a DDoS attack, which caused disruption in the services of several Internet Service Providers (ISP) in the State.

Another malware, Mirai, using a botnet of 5 lakh devices, had caused the servers of Dyn, a leading domain name service provider, to crash, affecting services of popular websites like Twitter, Netflix and Reddit.

Can hashgraph unseat blockchain as the favoured tech for cryptocurrencies?

Even as individuals and companies are trying to wrap their heads around, and take advantage of, cryptocurrencies such as bitcoin and ethereum and the underlying technology called blockchain, a new kid on the block named hashgraph is challenging the dominance of blockchain—a distributed ledger technology (DLT) that has been around for almost a decade.

US-based start-up HederaHashgraph insists that unlike blockchain, hashgraph can provide the speed required for multiplayer gaming, stock market transactions, micro payments, and food and in-app purchases.

With blockchain, which is finding favour with financial institutions and even manufacturing firms in India, each participant has a copy of the ledger's data that contains the most recent transactions or changes, thus reducing the need to establish trust using traditional methods.

"Hashgraph has all these features," insists Paul Madsen, technical lead at Hashgraph, and is also capable of processing hundreds of thousands of transactions per second, compared with bitcoin (less than 10 per second) and ethereum (less than 25 per second).

Hashgraph further offers "consensus time-stamping", according to Madsen, which prevents an individual from affecting the consensus order of transactions—by not allowing anyone to manipulate the order of transactions. On the other hand, "a miner (in the blockchain world) can choose the order in which transactions occur in a block, can delay orders by placing them in future blocks, (and) even stop them (users) entirely from entering the system".

Madsen points out that if two miners create two blocks simultaneously, the community will eventually select one and discard the other, resulting in wastage of efforts. "In hashgraph, no container (block) is discarded," he adds.

Over the next couple of years, HederaHashgraph hopes to introduce "a viable cryptocurrency—one that has seconds of latency like a credit card and not an hour as in

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

bitcoin; one that has fees of pennies and not \$10 dollars; and one that users will be willing to use because its value is stable and not wildly fluctuating based on speculation”, says Madsen.

Experts perceive hashgraph as a promising technology and one that has fewer limitations when compared to blockchain but add that it’s too early to predict whether hashgraph will unseat blockchain.

For one, blockchain is a more proven technology than hashgraph. Jaspreet Bindra, senior vice-president, digital transformation at Mahindra Group, points out that large banking, financial services and insurance (BFSI) firms and governments across the world are increasingly testing blockchain proofs of concept (or PoCs).

“For example, Mahindra Group successfully tested a bill discounting product on blockchain while NitiAayog is building and testing Indiachain for a PoC around educational degrees, certificates,” he adds.

Bindra, however, acknowledges that while blockchain is “excellent in terms of consensus-driven security and trust, along with provenance, the very consensus-building attribute of blockchain slows it down considerably”.

“Large public blockchains like bitcoin can only process 7-8 transactions per second, as opposed to Visa’s 30,000-50,000 per second, for example. This is because each proof of work has to be ratified by consensus across all participants or nodes. Therefore, most enterprises tend to go build private blockchains, with fewer nodes and consensus points, rather than using public blockchains. While this improves speed and scalability, the very properties of blockchain—trust, security, vulnerability to DDOS (distributed denial of service) attacks—get diluted,” explains Bindra. He believes that hashgraph “seems to solve this problem through some very clever algorithmic treatment and architecture”.

JayanthKolla, founder and partner of research and advisory firm Convergence Catalyst, acknowledges hashgraph is one of the leading technologies among Directed Acyclic Graph (DAG)-based blockchains. “It belongs to the third generation or what we call ‘Blockchain 3.0’ group”.

Hashgraph, he notes, is also a one-of-the-family of blockchain technologies designed on FFM—fast, feeless, and minerless—concept. DAG-based blockchain technologies including hashgraph remove miner from the equation using “gossip about gossip” protocols, in which the machines on the network spread the transaction information and verify and authenticate, instead of the “gossip” protocol used by blockchain and ethereum where there is a dependency on the miner to solve the puzzle, verify and

authenticate the transaction. This enables hashgraph to handle 4,000 transactions per second.

India joins Europe’s satellite data sharing pool

India has joined Europe’s mega global arrangement of sharing data from earth observation satellites, called Copernicus.

Data from a band of Indian remote sensing satellites will be available to the European Copernicus programme, while designated Indian institutional users will in return get to access free data from Europe’s six Sentinel satellites and those of other space agencies that are part of the programme, at their cost.

The space-based information will be used for forecasting disasters, providing emergency response and rescue of people during disasters; to glean land, ocean data; and for issues of security, agriculture, climate change and atmosphere, according to a statement issued by the European Commission here.

The agreement was signed in Bengaluru by Philippe Brunet, Director for Space Policy, Copernicus and Defence, on behalf of the EC and by P.G. Diwakar, Scientific Secretary, and Indian Space Research Organisation.

The multi-billion-euro Copernicus is Europe’s system for monitoring the earth using satellite data. It is coordinated and managed by the EC.

Range of applications

The free and open data policy is said to have a wide range of applications that can attract users in Europe and outside. The Copernicus emergency response mapping system was activated on at least two Indian occasions — during the 2014 floods in Andhra Pradesh in October 2014 and after the 2013 storm in Odisha.

“Under this arrangement, the European Commission intends to provide India with free, full and open access to the data from the Copernicus Sentinel family of satellites using high bandwidth connections. Reciprocally the Department of Space will provide the Copernicus programme and its participating states with a free, full and open access to the data from ISRO’s land, ocean and atmospheric series of civilian satellites (Oceansat-2, Megha-Tropiques, Scatsat-1, SARAL, INSAT-3D, INSAT-3DR) with the exception of commercial high-resolution satellites data,” the EC said.

The arrangement includes technical assistance for setting up high bandwidth connections with ISRO sites, mirror servers, data storage and archival facilities.

Centre issues notice to Cambridge

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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

Analytica

The government has sent a notice to U.K.-based Cambridge Analytica — accused of misusing data of 50 million Facebook users — asking it to disclose if data of Indian users was used, and to name the entities that used their services.

The firm has been asked to reply by March 31.

“The Ministry of Electronics & Information Technology, Government of India has issued a notice, in the first instance, to Cambridge Analytica, wherein the serious breach of propriety and misuse of data intended to profile and influence voting behaviour has been highlighted,” an official statement said.

Political parties in India, including the ruling BJP and the Congress, have accused each other of engaging the services of Cambridge Analytica, leading to questions over influencing elections “through questionable means.”

“The fairness of Indian democracy and electoral process is a matter of pride and any attempt to influence the sanctity of the electoral franchise through dubious and questionable means is unacceptable,” the Ministry of Electronics and IT said in a statement.

The notice addressed to Cambridge Analytica seeks immediate response to six questions, including “whether they have been engaged in any assignment to utilise data of Indians from the above cited breach? Who are the entities that have engaged them for the above?”

They have also been asked to clarify how they came to be in possession of such data? And was consent taken from the individuals?

“How such data collected was used? Was there any profiling done on the basis of such data?,” the Ministry asked.

How the Facebook-Cambridge Analytica saga unfolded

Facebook Inc. is under fire following reports that the personal data of 50 million users were obtained by an analytics firm that helped elect President Donald Trump. Lawmakers and regulators in the US and UK are now scrutinizing the social media giant, whose shares have dropped more than 9% since the news broke on 17 March.

1. Who took what from Facebook?

During the summer of 2014, the UK affiliate of US political consulting firm Cambridge Analytica hired a Soviet-born American researcher, Aleksandr Kogan, to gather basic profile information of Facebook users along with what they chose to “Like”. About 270,000 Facebook users,

most or all of whom were paid a small amount, downloaded Kogan’s app, *thisisyourdigitallife*, which took the form of a personality survey. Kogan collected data not just on those users but on their Facebook friends as well, if their privacy settings allowed it—a universe of people that reached 50 million. The app, in its terms of service, disclosed that it would collect data on users and their friends.

2. Did Kogan have Facebook’s permission?

In a general sense, yes. Since 2007, Facebook has allowed outside developers to build and offer their own applications within its space. When Kogan offered his app, Facebook also allowed developers to collect information on friends of those who chose to use their apps if their privacy settings allowed it.

3. Then what’s the issue here?

Facebook says Kogan “lied to us” by saying he was gathering the data for research purposes and violated the company’s policies by passing the data to Cambridge Analytica. (Kogan has said the app’s terms and conditions were written to allow commercial uses.) Facebook says that after it learned of the situation in 2015, it removed Kogan’s app and demanded that he “and all parties he had given data to” destroy the data. Facebook says it received assurances that the data was destroyed, though recent media reports say it wasn’t. Cambridge Analytica has maintained that it deleted all the data Kogan provided.

4. Why did Cambridge Analytica want the Facebook data?

The firm uses data to reach voters with hyper-targeted messaging, including on Facebook and other online services. The company may have wanted the data to create psychological profiles that could be used to target voters during political campaigns. The firm believed those profiles were better predictors of how voters could be swayed through targeted ads than traditional data on party registration and voting patterns. Cambridge Analytica was funded by former Renaissance Technologies co-CEO Robert Mercer, a major supporter of Trump in 2016. Trump’s campaign manager, Steve Bannon, served on the firm’s board.

5. Did Cambridge Analytica pay Kogan?

It covered his costs in creating his app—more than \$800,000—and allowed him to keep a copy for his own research, *The New York Times* reported, citing company emails and financial records.

6. Did the Facebook data help Trump win the presidency?



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Science and Tech.

The Crux of The Hindu

Vol. 13

News of Jan-Mar18

Whether Cambridge Analytica's models really work is a point of contention; even some of the firm's clients have said they saw little value in it. Cambridge Analytica has denied it used psychographic modelling techniques on the Trump campaign. But it's not clear whether the firm used the Facebook data in other ways to better understand and target voters. Also unknown: how many of the 50 million Facebook users whose data were acquired were registered US voters.

7. Did any of this violate any rules?

That remains to be seen. The UK has data-protection laws that ban the sale or use of personal data without consent. And in 2011, Facebook settled privacy complaints by the US Federal Trade Commission by agreeing to get clear consent from users before sharing their material. The FTC is now investigating whether Facebook violated the terms of that 2011 consent decree. The company would face millions of dollars in fines if it were found to have violated that pact. Lawmakers in the US and UK are conducting their own inquiries.

Indigenous technology tested on BrahMos

The BrahMos supersonic cruise missile was successfully test-fired with an indigenous seeker for the first time. So far the seeker, a critical technology in missiles, came from Russia.

"BrahMos, the formidable supersonic cruise missile with indigenous seeker was successfully flight tested at 08:42 hrs at the Pokhran test range in Rajasthan. The precision strike weapon with indigenous seeker flew in its designated trajectory and hit the pre-set target," the Defence Ministry said in a statement.

Expert tie-up

The seeker was jointly developed by the Defence Research and Development Laboratory (DRDL), Hyderabad, and BrahMos Aerospace.

Seeker technology, which determines the accuracy of a missile, is a closely guarded secret. Mastering it is a significant milestone in missile technology and would reduce import dependence.

BrahMos is joint collaboration between India and Russia and is capable of being launched from land, sea, sub-sea and air against surface and sea-based targets.

The range of the supersonic missile was initially capped at 290 km as per the obligations of the Missile Technology Control Regime. Since India's entry into the club, the range has been extended to 450 km and the plan is to hit 600km.

FB apologises for breach of trust

"I started this when I was so young and inexperienced," Mr. Zuckerberg said. "I made technical errors and business errors. I hired the wrong people. I trusted the wrong people," he said.

He said the company will "investigate every app that has access to a large amount of information from before we locked down our platform, and if we detect any suspicious activity, we're going to do a full forensic audit."

"We're going to review thousands of apps," he said.

Facebook said it discovered last week that Cambridge Analytica might not have deleted the data as it certified.

"We should not have trusted Cambridge Analytica's certification, and we are not going to make that mistake again," he said.

"This was a breach of trust between Kogan, Cambridge Analytica and Facebook," Zuckerberg wrote in the post.

"But it was also a breach of trust between Facebook and the people who share their data with us and expect us to protect it."

Slew of measures

In a damage-control mode, he announced a slew of measures to secure the platform further.

The company would take three steps to prevent the data misuse. "We will investigate all apps that had access to large amounts of information before we changed our platform to dramatically reduce data access in 2014, and we will conduct a full audit of any app with suspicious activity," he said. "We will ban any developer from our platform that does not agree to a thorough audit. And if we find developers that misused personally identifiable information, we will ban them and tell everyone affected by those apps," he added.

Restricting data

Mr. Zuckerberg said the second step was to restrict developers' data access even further to prevent other kinds of abuse.

"We will reduce the data you give an app when you sign in — to only your name, profile photo, and email address. We'll require developers to not only get approval but also sign a contract in order to ask anyone for access to their posts or other private data. And we'll have more changes to share in the next few days," he said.

He said that next month, Facebook would show everyone a tool at the top of their News Feed with the apps they have used and an easy way to revoke those apps' permissions to their data.



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Science and Tech.

The Crux of The Hindu

Vol. 13

News of Jan-Mar18

Orkut to return to India in 'Hello' avatar

Orkut Buyukkokten, the creator of Orkut.com, one of the early and most famous social media platforms, is planning to unveil his new social media network 'Hello' in India in the next two months.

Mr. Buyukkokten, 42, who is already running the beta version of 'Hello' in the country, said his new venture connects people who share the same interests and passions and provides a place for authentic communication.

'Sense of togetherness'

"If you look at the Indian culture, people are so connected," said Mr. Buyukkokten, founder of Hello Network, Inc., in a phone interview. "There is a sense of togetherness and we are bringing that togetherness that we see in our daily lives on Hello."

Unlike other social networks, the firm said it was trying to create these connections in a non-judgmental environment.

A Turkish engineer, Mr. Buyukkokten had unveiled Orkut in 2004 as part of an independent project while working at Google.

A decade later, the Internet giant shut down the social networking service, which, at its peak, had gathered more than 300 million users worldwide.

Facebook, which was also founded in 2004, is now the leading social network in the world with more than two billion monthly active users.

"I see Orkut.com as a start of a wonderful journey. Social networks have evolved over time...I see 'Hello' as a continuation of this journey," said Mr. Buyukkokten.

An alumnus of Stanford University, Mr. Buyukkokten founded Hello in 2016 with a small group of ex-Google engineers.

The San Francisco-based firm is now present in 12 countries including Canada, New Zealand and Brazil, and is available for Android and iOS devices.

Backed by a group of investors including Google, the firm has grown to a team of 20.

Hello said that social networking today is about broadcasting content, privately messaging, and anonymously having a say on discussion threads.

Bridging the gap

It said there is a gap that does not provide an environment where one can easily connect and make friends with like-minded people who share the same interests. The firm said it is trying to bridge this gap. For instance, it has a feature called 'personas' which will allow users to pick the five most relatable traits that define them, such as an animal lover, cricket fan, dancer or a fashion en-

thusiast.

Hello said that communities were also created by the members letting the user be a part of something unique and specific to his or her interests like sci-fi movies.

'Exchange ideas'

These communities give the user an opportunity to chat and exchange experiences with others who share those deep interests.

"We are trying to create happier life online," said Mr. Buyukkokten. "We are creating a new type of experience that is welcoming and accepting (and) where people share their genuine feelings and passions," he said.

India will have more than 850 million online users by 2025, more than the combined populations of the G7 countries, according to a report from Boston Consulting Group.

Report highlights India's digital divide

The southern State of Kerala seems far ahead of all Indian States in breaching the digital divide, if the data generated by Pratham's Annual Status of Education Report, 2017, for its sample district of Ernakulam are to be believed.

And the eastern State of West Bengal seems right at the bottom in terms of the rural youth's access to the Internet, computers and mobiles, as per data generated from its South 24 Parganas district.

Even as the government looks at ushering in a Digital India, ASER 2017 offers a snapshot into how different States are faring in breaching the digital divide, by focusing on rural youth in the 14-18 age group in 28 rural districts across 24 States in India.

A pointer

The patterns may not hold true or all districts in particular States, but may be a pointer to the south's lead and the eastern States' backwardness in rural digital access.

Significantly, 69.8% of the rural youth surveyed in Kerala's Ernakulam district had used the Internet in the week before the survey. Similarly, 92% had used mobile phones and 60% had used computers in the week leading to the survey. It was also the only district among those surveyed across India where a third of the rural youth had used an ATM.

The surveyed districts of Amritsar and Bhatinda and Maharashtra's Satara and Ahmednagar also showed decent digital access, though well below Kerala.

West Bengal lay at the other end of the spectrum, faring worst in breaching the digital divide.

Just 17.1% of the rural youth between 14 and 18 in West

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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

Bengal's South 24 Parganas district had used the Internet in the week leading to the survey. Just 21.2% had used a computer and 65.5% had used a mobile phone.

Never used

In Kerala's Ernakulam, just 10.5% of the surveyed rural youth had never used the Internet and 0.4% had never used a mobile phone.

The situation was much worse in eastern States, however.

While nationally, 63.7% of the rural youth surveyed had never used the Internet, the figures were much higher in districts in West Bengal, Bihar, Odisha, Jharkhand and Assam.

In West Bengal's South 24 Parganas district 74.4% rural youth in the age group of 14 to 18 years had never had access to Internet while in Odisha's Khordha district, the number was 65.8%. In Jharkhand's PurbiSinghbhum the figure stood at 68.8% and in Bihar's Muzaffarpur district 67.5%. In Assam's Kamrup district the number was 64.1%.

MHA-CYBERCRIME

To deal with cybercrimes, the Union Home Ministry is planning to set up an apex coordination centre and has asked the States to establish a similar mechanism. It has also released Rs. 83 crore for setting up of a cyberforensic training laboratory-cum-training centre for police officers in each State.

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The Crux of The Hindu
Vol. 13
News of Jan-Mar18

DEFENCE

India test fires medium-range nuclear capable Agni-II missile

India test-fired its medium-range nuclear-capable Agni-II missile with a strike range of 2,000 km from Abdul Kalam Island off Odisha coast, Defence sources said. The trial of the surface-to-surface missile was conducted from a mobile launcher at the Launch Complex-4 of the Integrated Test Range around 8.38 am, the sources said.

Agni-V extends its reach

India successfully tested Agni-V, validating the long range surface-to-surface ballistic missile's reliability.

"This was the fifth test of the missile and the third consecutive one from a canister on a road mobile launcher. All the five missions have been successful," the Defence Ministry said in a statement.

The missile was tested for its full range at 9.53 a.m. from the Dr. Abdul Kalam Island in Odisha. The launch was supervised by project director G. Ramaguru and programme director M.R.M. Babu. The flight performance of the missile was tracked and monitored by radars, range stations and tracking systems all through the mission.

"All objectives of the mission have been successfully met," the Defence Ministry statement added.

A cornerstone

Agni-V, with a range of over 5,000 km, is India's longest range ballistic missile and can reach most parts of China, making it the mainstay of India's triad to deliver nuclear weapons.

The user associate test-flight of the missile has further boosted indigenous missile capabilities and deterrence strength of the country.

Describing the trial as "fully successful," the sources said, the sophisticated missile travelled for 19 minutes and covered 4,900 km.

Agni-V is the most advanced missile in the Agni series with new technologies incorporated in it in terms of navigation and guidance, warhead and engine.

"The navigation systems, very high accuracy Ring Laser Gyro based Inertial Navigation System (RINS) and the most modern and accurate Micro Navigation System (MINS) had ensured the missile reached the target point within few metres of accuracy. The high speed on-board computer and fault-tolerant software along with robust

and reliable bus guided the missile flawlessly," said an official of the Defence Research and Development Organisation.

The missile is so programmed that after reaching the peak of its trajectory, it will turn towards the Earth to continue its journey towards the intended target with an increased speed due to the attraction of the Earth's gravitational pull, he said.

Its path is precisely directed by the advanced on-board computer and inertial navigation system, the official added.

Short preparation time

The first two successful flights of Agni-V in 2012 and 2013 were in open configuration.

The third, fourth and Thursday's launch from a canister, integrated with a mobile sophisticated launcher, were in its deliverable configuration that enables launch of the missile with a very short preparation time as compared to an open configuration. It also has advantages of higher reliability, longer shelf life, less maintenance and enhanced mobility.

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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

Agriculture

IIT Hyderabad's novel composite keeps tomatoes fresh for 30 days

Researchers at Indian Institute of Technology (IIT) Hyderabad have been successful in keeping tomatoes fresh and without any microbial spoilage for as long as 30 days. This was possible thanks to the food packaging material developed by a two-member team led by Dr. Mudrika Khandelwal from the institute's Department of Materials Science and Metallurgical Engineering. The food packaging material is made of bacterial cellulose impregnated with silver nanoparticles.

Bacterial cellulose was first prepared by using *Gluconacetobacter xylinus* bacteria to produce semicrystalline cellulose nanofibre from a standard glucose media. "We can use any fruit juice that is rich in sugar or even beer and wine, which are fermented, to produce bacterial cellulose," says Dr. Khandelwal.

Nanofibrous

Bacterial cellulose is highly crystalline, has high porosity and water holding capacity and possesses great mechanical properties. Also, bacterial cellulose is nanofibrous unlike plant cellulose, which is microfibrillar. The results were published in the *Journal of Materials Science*.

The bacterial cellulose was first treated with sodium hydroxide to remove all bacteria and then impregnated with silver nanoparticles. This was done by dipping the bacterial cellulose in silver nitrate solution and subsequently in sodium borohydride solution. Reduction of silver nitrate to form silver nanoparticles happens inside the pores of the bacterial cellulose.

The nanosized pores present in the bacterial cel-

lulose matrix restricts the growth of nanoparticles, thereby controlling their size. It prevents the nanoparticles from forming aggregates. "We found that the smaller the size [5-6 nanometres] of the silver nanoparticles the better was the antimicrobial activity. There was also sustained release of nanoparticles," she says. This was not the case with silver nanoparticle colloid where the nanoparticles tend to form aggregates.

The antimicrobial activity of bacterial cellulose was first tested on bacteria and fungi isolated from rotten tomatoes and later on mixed culture. Compared with controls, the composite (bacterial cellulose impregnated with silver nanoparticles) showed 99% killing efficiency. The antibacterial activity was successfully tested up to 72 hours. The antibacterial activity of colloid was only 90%. "The bacterial cellulose with silver nanoparticles not only had activity against bacteria but also against fungus," says Dr. Khandelwal.

The researchers then tested the antimicrobial efficacy of the composite by using it to wrap freshly harvested tomatoes. Tomatoes wrapped in polyethylene (polythene) and polypropylene served as controls.

Fresh tomatoes

At room conditions, tomatoes wrapped in the composite remained fresh without any wrinkles or microbial spoilage even at the end of 30 days.

"This is because besides antimicrobial activity, the composite also allows appropriate exchange of gases and moisture. The water holding capacity of the composite helps maintain optimum moisture transmission," says Shivakalyani Adepur from the Department of Materials Science and Metallurgical Engineering at IIT Hyderabad and first author of the paper. "The composite also acts as ethylene blocker thus preventing excess ripening of fruits. It ensures that fruits age slowly."

On the contrary, tomatoes wrapped with polyethylene started wrinkling within the first week, and mi-



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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

crobial spoilage was seen within 15 days; tomatoes had completely deteriorated within 30 days. But in the case of polypropylene, tomatoes remained fresh for a week; they started wrinkling within 15 days and became soft and wrinkled all around within a month.

“We want to test our composite on exotic fruits,” says Dr. Khandelwal. “We would also like to extend the same principle to healthcare products. The composite can be used as antimicrobial lining in sanitary napkins, and disposable clothing and covering in hospitals.”

Centre urged to check spread of BG-III cotton

Telangana government has requested the Centre to formulate protocols and guidelines at the earliest to take steps to check the spread of herbicide tolerant variety cotton seed, popularly known as BG-III, which is not cleared by the Genetic Engineering Approval Committee (GEAC), and is harming the biodiversity in the country.

A detailed presentation was made on the unauthorised spread of the unapproved cotton variety by Director of Telangana State Seed and Organic Certification Authority K. Keshavulu here before the visiting team of Field-level Inspection and Scientific Evaluation Committee (FISEC) appointed by the Centre on the issue of BG-III. He also explained the initiatives taken by the State government in bringing the issue to the Centre's notice constantly. The high-level team comprising officials from the Indian Agricultural Research Institute (IARI), Department of Biotechnology (DBT), Central Institute for Cotton Research (CICR), Ministry of Environment, Forests and Climate Change (MoEF&CC) and Prof. Jayashankar Telangana State Agricultural University visited Jogulamba-Gadwal and Vikarabaddistricts andMancherial district before meeting the stakeholders, including seed growers, dealers, national and State seed associations at a meeting here.

Leader of the visiting team, chief scientific officer in DBT, V.S. Reddy, complimented the efforts of Telangana government in highlighting the issue at national-level. The team arrived in Telangana after studying the issue in Gujarat and would be in Andhra Pradesh for the next two days.

Agriculture Production Commissioner C. Parthasarathi said all the stakeholders are in total confusion on the issue of BG-III in the absence of any guidelines from the Centre since the seed was unapproved.

Tea growers seek help to fight climate change

The tea industry wants the Centre to help it fight climate change, which is affecting crop output. The common ground between the large estates and small tea growers — now an emerging force in the Indian tea industry — seems to be the incentives they are seeking to support the farm practices that have become necessary to combat climate change. Small tea-growers, who have begun carving out an increasing share in India's total crop, are urging the Centre to adopt a more farm-centric approach — one which would assist a majority among them, who grow tea on less than an acre.

“They are essentially farmers and they need schemes to protect them from the impact of climate change and resultant crop loss,” the Confederation of Indian Small Tea Growers Association said in a representation to the Centre. “We strongly urge the government of India to implement crop insurance schemes and invest in preparing farmers.”

Irrigation facilities

As erratic climate continues to affect output, the industry's focus is on creating irrigation facilities and on replanting the older tea bushes. Almost 38% of the area under cultivation comprises tea bushes which are more than 50 years old. While the younger 10-year-old bushes cover 26% of the area, about 9-10% each fall in the intervening decadal catego-



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Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

ries spanning 11-50 years. The age of a bush is directly linked with yield.

Industry gets support for its investment in this regard through income tax deductions, with the floor limit set at Rs. 25 crore. This limit ought to be removed so as to enable investment in plant and machinery for irrigation, according to the industry.

The problem of small farmers having to face heavy crop loss due to recurring instances of hailstorms, frost, rains and droughts, in the absence of any system to compensate them, is another concern.

“We strongly urge the government to implement crop insurance schemes and invest in measures that would prepare farmers to face the challenge of climate change,” the growers’ body said. It also wanted the government to declare minimum support price for green tea leaf produced by small growers.

According to the Tea Board, small growers accounted for 44% of the 1,250.5 million kg of tea crop in 2016-17.

The organised tea industry, which is weighed down by social costs (mandated under the Plantation Labour Act and covering areas like housing, medical, potable water and subsidised rations), is also keen to see some direct tax relief for these expenses. Customs duty on specified machinery was 5% in 2003 and through yearly extensions continued at this level till 2011. Industry contends that the moderate increases in price do not cover the rise in inputs costs.

In respect of GST, the industry has sought some simplification and removal of anomalies that are affecting exporters.

On the value-added export front (tea bags), industry is looking for concessional duty on filter paper, multi-wall paper and nylon cloth which is required for making tea bags.

“These products are either not available in the domestic market or of poor quality. Total duty incidence on these papers is very high making India uncompetitive,” industry said.

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The Crux of The Hindu
Vol. 13
News of Jan-Mar18

MISCELLANEOUS

The 'Sanskrit effect' and how rigorous memorising helps the memory

Considerable excitement has been triggered through email and social media across India due to a recent "observation" reported by one Dr James Hartzell in the journal *Scientific American*. This neuroscientist has coined the term "The Sanskrit effect." He writes that memorising Vedic mantras increases the size of brain regions associated with cognitive function such as memory (both short-term and long-term). He writes in his report that Indian tradition holds that rigorously memorising and reciting mantras enhances memory and thinking. In order to test this idea, Hartzell (and his colleagues from the University of Trento in Italy) teamed up with DrTanmayNath and DrNandini Chatterjee Singh of the National Brain Research Centre (NBRC) at Manesar in Haryana. They chose to study 42 volunteers — 21 professionally qualified Sanskrit Pandits (aged around 22) who have been trained full-time daily for 7 years (total of over 10,000 hrs) in their childhood reciting the Shukla Yajurveda. These Pandits were recruited from Vedic Pandit schools in Delhi. As control, they chose 21 age-matched males, students from a nearby college.

Brain imaging

The brains of all the 42 participants were examined using the method called structural magnetic resonance, with the magnetic resonance imaging instrument at NBRC. This method allows the study of the size and shape of individual parts of brain. The so called grey matter (GM) of the brain is a region full of neuronal cells, and contains areas involved in muscle control, sensory perception, memory, emotions, speech and decisionmaking. And connected to it is white matter (WM) — bundles of nerve cells that carry signals to GM. The hippocampus is a small organ located within the central region of the brain, and it registers and regulates emotions associated with memory (particularly long-term memory) and has front and back sections. The back part appears associated with better memory and supports recollection of memory. And the cortex, which is the outermost layer surrounding the brain (essentially a cover or envelope), with its tightly packed nerve cells, is responsible for higher thought processes such as decisionmaking.

The Indo-Italian team analysed the brain regions of the

21 Pandits and 21 control volunteers and found some remarkable differences between the two. They found the grey matter in Pandits to be denser and the cortex thicker than in 'controls', and the hippocampus regions, associated with long- and short-term memory was more pronounced. (Interested readers can access this paper free at <http://dx.doi.org/10.1016/j.neuroimage.2015.07.029>). Indeed, a similar experiment, again using Vedic Pandits (this time in Houston, TX, USA), was done earlier by DrGiridharKalamangalam and T. M. Ellmore (accessible free in *Frontiers in Human Neuroscience*, 2014 Oct 20;8:833. doi: 10.3389/fnhum.2014.00833. eCollection 2014), and they too noted thicker cortex in the Pandits than in controls.

Importantly, these changes in the brain are not temporary but stay for long. That means that the power of memory, decisionmaking, sensory perception and such would last longer in those who were trained earlier. Dr Danker and Dr Anderson, who were studying this aspect, actually titled their 2010 review as "The ghosts of brain states past; remembering reactivates the brain regions engaged during coding" (*Psychol. Bull.*, 136, 87-102. doi: 10.1037/a0017937). Here coding refers to the earlier rigorous practice and memorising.

Not special to Sanskrit

It is also important to realise that one need not attach any special power to Shukla Yajurveda as a brain enhancer. Fifty years ago, a French scientist noted that Christian monks who chanted the Gregorian Chants have exceptional memory (though no brain scanning methods were available at that time). Further, it need not be verbal or religious chanting at all. It could be visual and spatial training too. Dr Eleanor Maguire and colleagues studied the brain structures of the taxi drivers of London, each one having gone through a vigorous and extensive course called "The Knowledge." In this course, each driver is taught and had to memorise the spatial location of every street, monument and tourist spot across greater London before being given a taxi driver license. He needs no GPS; it is all in his hippocampus, GM and cortex. (Interested readers may access *Proc Natl AcadSci U S A*. 2000 Apr 11; 97(8): 4398-4403. doi: 10.1073/pnas.070039597). One is also reminded of how the multiplication tables we had learnt by rote in primary school in India comes in handy decades later when we go shopping in stores.

(Incidentally, several years ago, a scientist claimed that listening to the music of the European composer Mozart helps in memory and smartness and termed this the "Mozart Effect". School children were asked to do some

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The Crux of The Hindu
Vol. 13
News of Jan-Mar18

tasks while listening to Mozart, and they did better than when Mozart was not played. This led a rush by parents to music stores to buy and play Mozart to their children. Soon enough, it was found that the effect lasts only when the music was played; the kids felt more relaxed and smoothed; after the music stopped, the effect vanished. The Mozart effect did not last long).

Systemic exercise

These studies also raise the possibility that we may exert or exercise our brains by doing “memory training,” even during later life when we are old, and need not have been Pandits, Gregorian monks or London cabbies. Indeed, the paper by A. Engwig and colleagues talks about how systemic mental exercise may induce short-term structural change in the ageing brain (in the journal *Neuroimage* in 2010; short summary accessible at doi: 10.1016/j.neuroimage.2010.05.041). They show memory trainees to have increased cortical thickness than controls do. Just as physical exercise helps our brawn, mental exercise helps our brain. So, let us seniors do word puzzles and games, learn (relearn) languages, practice music, chant Gregorian or Vedic texts (but in the proper chanda or metre), and our brains can still be young.

An electronic ‘nose’ model from IIT Bombay

Dogs are often used to sniff out the presence of explosives and drugs by the police. Now, at the Electrical Engineering department of Indian Institute of Technology, Bombay, research is on to develop an “electronic nose” which can avoid this altogether. Based on the process of inelastic quantum tunnelling, the “nose” can differentiate between molecules based on their vibrational energies.

How do we smell?

There are two competing theories that try to explain olfaction, or the action of smelling – the shape theory and the vibration theory. According to the shape theory, the shape of a particular molecule acts as a “key” and fits into the “lock” in the nose, thereby stimulating it to perceive a smell. The vibration theory, on the other hand, proposes that the nose senses not the shape but the vibrational energy of the odorant molecule. Perhaps the actual mechanism is even a combination of the two processes, While the argument goes on, the IIT Bombay researchers have showed that, using inelastic quantum mechanical tunneling, it is possible to construct an artificial “nose” that differentiates between different odorant molecules by sensing their vibrational energies. Quantum effects can get washed out at room temperature, but they propose a

way that is sturdy even at room temperature.

The nose they have proposed is actually a one-dimensional “resonant tunneling diode” – a quantum device that conducts only when it is excited by special discrete values of electrical energy. Essentially this is a modification of a quantum wire – a linear array in which the electrons can move in one dimension only. “Our device takes a quantum wire a little further in a modification without which we do not see room-temperature operation. It adds a double barrier structure — with a [potential] well in the middle — in the transport direction as well,” says SwaroopGanguly, one of the authors of the paper published in *Scientific Reports*. A double potential barrier (like two barricades) is created on the quantum wire, which confines the electrons further to be enclosed in a small region. It is known in quantum mechanics that this allows the confined electrons to possess discrete values of energy. This device selectively allows electrons with specific resonant incident energies to tunnel through the barriers.

Vibrational mode

“The resonant tunneling diode shows a peak in the current but does not shut down completely away from the peak. The way the odorant molecule information enters is through the creation of a vibrational mode that modulates the current, specifically by opening up an inelastic channel for tunneling wherein the electron loses energy in the form of vibration,” explains Prof. Ganguly. Normally such vibrational signatures are washed out at higher temperatures, but the paper shows that for the proposed device they would persist at room temperature.

Making the device involves fabricating a one-dimensional semiconductor device with a double barrier, using standard semiconductor fabrication technology. “This is the approach we are embarking on now, with my colleague DipankarSaha, also a co-author on this paper, who fabricates these really beautiful one-dimensional structures here in IIT Bombay’s Nanofabrication Facility,” Prof. Ganguly adds.



Moth-proofing wool fabric

Using a cheap and easily available natural mineral, scientists from Central Sheep and Wool Research Institute (ICAR-CSWRI), Rajasthan have now moth-proofed woollen fabric. The moths did not consume the woollen fabric when treated with 1% nano kaolinite (an aluminium

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

silicate clay mineral). The mineral costs just Rs 95/ kg while the existing anti-moth chemical (Eulan), which is imported, costs Rs 2,000/kg. The results were published in The Journal of the Textile Institute.

A moth feeds on a protein present in the woollen fabric; a moth larva can consume about 40 mg of wool in a month. The researchers treated wool with different concentrations of nano-kaolinite solution and found just 1% was sufficient to protect the fabric.

They adopted two different methods of wool treatments. One method was addition of kaolinite (dispersed in water) to fabric, followed by heating at 80 degree C for 30 minutes before water rinsing it. In the second method, fabric was dipped in the kaolinite dispersion for 30 minutes, squeezed and kept for 24 hours at room temperature and then water rinsed.

"The second longer treatment for 24 hours gave better moth repellence with lesser fabric damage," says Seiko Jose from the Textile Chemistry Division and the first author of the paper.

To test the effectiveness of moth-proofing, the treated wool was placed in a Petri dish along with 10 adult moths for 15 days in a dark chamber. They also conducted the same test with wool treated with a commercially available agent. The natural mineral treated wool showed a weight loss of just 1.5% while untreated one was 12.85%. It was 0.5% in the case of fabric treated with the imported agent (Eulan).

The researchers applied different concentrations of natural nano kaolinite and commercial anti-moth agent directly on the moth to study contact toxicity. Just 0.05% of the chemical killed the moth within a short span of time while the natural solution caused no or less toxic effect upon direct contact.

"It only stopped the moth from eating the wool and starved it to death. We think that the bitter taste of the natural mineral, triggered the deterrent receptor in the insects brain and signalled not to eat the wool," adds Dr Seiko "The nano-kaolinite is ecofriendly and causes no harm to humans and aquatic environment when the treated woollen fabric is washed," says Dr. Ajay Kumar from the Textile Chemistry Division and one of the authors of the paper.

Skewed sex ratios induce same-sex behaviour in pigeons

It's all about making the best of a bad job: if there is a paucity of males, female rock pigeons can form long-lasting, same-sex relationships to bring up their chicks,

find scientists. Such female pairs fare no differently than female-male pairs, and better than single females, in bringing up their brood.

Numerous records of same-sex sexual behaviour exist in the natural world and more than 130 bird species have been recorded displaying such behaviour, ranging from courtship displays and copulation to establishing nesting territories. Theories put forward to explain this include 'social glue' (where engaging in same-sex bonds establishes strong social relationships), 'alloparenting' (that females have a fluid sexuality that helps them form same-sex bonds if their partners die or leave, which is useful to bring up offspring) and the 'prison effect' (removing one sex causes the rest to engage sexually with members of its own sex).

A team of scientists from Poland tested what would happen if males or females are removed from populations of rock (feral) pigeons, a monogamous species (which has only one mate at a time) that is also found in India.

In their study published in Scientific Reports, the scientists detail how they established three feral pigeon colonies between 2007 and 2009. From the first colony, they removed several males that had already paired with females. This skewed the sex ratio towards females, creating not just the existing female-male (f-m) pairs but also five female-female (f-f) pairs and 14 single females. Males from the f-m pairs fertilised the single females and those in the f-f pairs.

The team found that egg incubation time, development of chicks and numbers of hatchlings of f-f pairs was almost the same as f-m pairs, while single females did not do as well.

The removal of females from the second colony created only two short and unstable male-male pairs, which did not build nests or adopt offered eggs. From the third colony, when the team removed females whose fledglings were growing, males displayed mating behaviour towards their offspring.

"Our results show that a shortage of males evokes same-sex sexual behaviour in females in an effort to adapt and compensate for the lack of males," writes lead author Łukasz Jankowiak (University of Szczecin) in an e-mail to The Hindu. According to Jankowiak, both alloparenting in females and prison effects in both females and males explain same-sex sexual behaviour in this case.

Roadkills of wild animals in the Ghats

The roads that Valparai's tourists love driving through to spot wildlife also see numerous animal deaths. Road

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

surveys show that almost 3,000 animals died on approximately 1,500 km of roads in Tamil Nadu's Valparai plateau in 2011-12 alone.

Valparai's road network meanders through rainforest fragments and tea, coffee, cardamom and eucalyptus plantations in the Anamalai Hills of the Western Ghats. Along with people, animals – including endangered Asian elephants and lion-tailed macaques – also live on this high-elevation plateau. However, fragmentation of habitats ensures that wildlife have to cross roads when they move about. A study recorded 73 reptile deaths on the Valparai roads in 2001; mammal and insect deaths are also frequent here.

Scientists of the Nature Conservation Foundation (NCF) walked along eleven road sections passing through various habitats in the Valparai plateau. They noted roadkills of all animal taxa across seasons (surveying totally 1473.4 kms, including a State Highway) in 2011-12.

Their results, published in the journal *Current Science*, show that 2,969 animals died on Valparai's roads during this time, which translates approximately to an average of 21 animals per 10 km of road. Almost 50% of these kills comprised amphibians — toads, frogs and caecilians (limbless, snake-like amphibians). Rodents and shrews comprised a majority of the 148 mammal kills. The Indian crested porcupine, the brown palm civet (a fruit-eater endemic to the Western Ghats), larger mammals like sambar deer and endemic lion-tailed macaques also figured in the list of mammal roadkills.

When the team compared deaths across seasons, they found that roadkill rates were 2.4 times higher during the monsoons than during summer. This could be because many amphibians breed and move across land during the monsoon, write the authors. What habitat the road passed through also mattered; roads passing through tea plantations, followed by forests habitats, saw the highest deaths at 1,402 and 948, respectively. Forest patches had the highest mammal roadkills.

The team's findings could help identify specific management measures for different habitats to prevent or reduce roadkills in Valparai and similar places. According to the authors, roads through forest patches need urgent attention because forest-dependant and endemic species died most here. Drains along roadsides with underpasses at regular intervals can also provide safe passages for small-sized taxa like amphibians.

"But mitigation measures have to be taxa- and habitat-specific, and should be implemented on road stretches which see a lot of roadkills," said P. Jeganathan (NCF),

lead author of the study.

IIT Kanpur researchers find why babies need to move in the womb

Formation of joints in the developing embryo and their maintenance after birth is sensitive to mechanical movement. Now, researchers at Indian Institute of Technology (IIT) Kanpur have deciphered the molecular mechanism underlying this phenomenon. They have demonstrated how permanent cartilage is formed in an embryo due to mechanical movement. They also found out how permanent cartilage is lost and temporary or transient cartilage is formed in its place in the absence of movement.

While permanent cartilage lines the joint, the transient cartilage is a bone-forming one. Earlier this group demonstrated that during embryonic development, a bipotential cartilage population gives rise to both permanent and transient cartilage. BMP and Wnt are two major signals regulating this process. While BMP promotes transient cartilage formation, Wnt promotes permanent cartilage formation.

In patients with osteoarthritis, the permanent cartilage acquires all the characteristics of a temporary cartilage, which affects joint function. Currently, in people with osteoarthritis, it is not possible to reverse the fate of permanent cartilage that has become a temporary-like cartilage. The work done by a team led by Prof. Amitabha Bandyopadhyay from the Department of Biological Sciences and Bioengineering at IIT Kanpur suggests that it might be possible to prevent osteoarthritis from worsening if intervened at an early stage. The results were published in the journal *Development*. The work was carried out in collaboration with the laboratory of Prof. Paula Murphy of Trinity College Dublin.

Transient cartilage

BMP signalling — which helps in the formation of transient cartilage — is normally not present in permanent cartilage cells in a joint? That transient cartilage forms in the place of permanent cartilage due to joint immobilisation was already known. And independently, the team had shown that BMP signaling promotes transient cartilage formation. "So we wanted to find out if immobilizing the joints in a chick embryo allows the BMP signaling to come up in the joint cartilage cells. We did find that happening," Prof. Bandyopadhyay says.

The investigation into what causes the BMP signaling to be present in future permanent cartilage cells when the joint is immobilised led them to a surprise finding. The lead author, Pratik Singh, found out that an inhibitor of



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

BMP signaling (Smurf1) is absent in the joint that is immobilised resulting in increased BMP signalling. “The role of the Smurf1 inhibitor is to maintain a BMP-free area thereby enabling the progenitor cells to become permanent cartilage. But due to increased BMP signalling the permanent cartilage gets converted into transient-like cartilage,” says Prof. Bandyopadhyay.

The Smurf1 inhibitor is not directly involved in joint cartilage formation but creates an environment that permits the formation of permanent cartilage by keeping the BMP signalling under check.

Toggle switch

Mechanical movement seems to act like a toggle switch. In the presence of it, Wnt – the signal that promotes joint cartilage – is on and BMP signalling is off in the joint cartilage cells. The opposite is true when the joint is immobilized. This is the reason why immobilisation of joints causes greater disturbance to permanent cartilage than even inhibition of Wnt signalling. “We are now investigating if osteoarthritis is also associated with appearance of BMP signalling in the wrong place. If so, we can block the BMP signalling in these cells during the early-stage of osteoarthritis to possibly prevent the condition from worsening,” he says.

Bizarre ‘alien’ skeleton was of human foetus: study

A six-inch skeleton discovered in Chile’s Atacama Desert belongs to a human foetus, and does not have extraterrestrial origins, scientists say. After five years of deep genomic analysis, researchers from the Stanford University and University of California, San Francisco (UCSF) in the US have pinpointed the mutations responsible for the anomalous specimen. They found mutations in not one but several genes known to govern bone development, researchers said.

The skeleton, nicknamed Ata was discovered more than a decade ago in an abandoned town in the Atacama Desert of Chile. After trading hands and eventually finding a permanent home in Spain, the mummified specimen started to garner public attention. Standing just six inches tall with an angular, elongated skull and sunken, slanted eye sockets, the internet began to bubble with other-worldly hullabaloo and talk of ET, said Sanchita Bhattacharya from UCSF, the lead author of the study published in the journal *Genome Research*.

After sequencing Ata’s genome, researchers found mutations in seven genes that separately or in combinations contribute to various bone deformities, facial malforma-

tions or skeletal dysplasia. The analysis pointed to a decisive conclusion: This was the skeleton of a human female, likely a foetus, that had suffered severe genetic mutations.

Nolan noted that 8% of the DNA was unmatchable with human DNA, but that was due to a degraded sample, not extraterrestrial biology. Later, a more sophisticated analysis was able to match up to 98% of the DNA, he said.

Neutrino project gets environmental nod

The India-based Neutrino Observatory (INO) project has got a fresh lease of life with the Ministry of Environment and Forests (MoEF) taking it up as a special case and granting it environmental clearance to set up the lab in Bodi West hills.

MoEF’s Expert Appraisal Committee (Infra 2), after detailed deliberations on the proposal and submissions by the project proponent, recommended this at its meeting on March 5. According to the minutes of the meeting available in the public domain, the EAC was given to understand that though the proposals were not within its scope, the Ministry wanted it to consider this as a special case.

The panel was informed that there was no scope for radioactivity and leaching of water and these have been explained to the courts. The project proponents clarified that studies showed there would be no impact of blasting on any habitation in the vicinity.

During the panel’s deliberations, an expert from the Defence Research and Development Organisation (DRDO) was present.

Two conditions

While granting EC, the committee stipulated specific conditions, of which two are key for the project to take off. One is the consent to establish and operate to be obtained from the Tamil Nadu Pollution Control Board (TNPCB). In the past, INO project proponents had complained that the TNPCB had been sitting on the file for years without taking any action when Jayalalithaa was Chief Minister (2011-16). Also, the INO team has to obtain the necessary forest and National Board for Wild Life clearances as per law. The Mathikettan Shola National Park in Idukki district, Kerala, is situated within five km from the project site.

When the project was considered by the Tamil Nadu State Expert Appraisal Committee in November 2017 (after Jayalalithaa’s death), it said that the proposed site forms part of the catchment area of various streams that contribute to the Vaigai watershed.



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

Therefore, Tamil Nadu was of the opinion that the proposal could not be appraised under category B of item 8(a) 'Building and construction projects of the Schedule to the EIA notification 2006', as it involved many technical features other than mere construction. The SEAC also said the project should be appropriately handled by the Centre. Incidentally, Deputy Chief Minister O. Panneerselvam represents the Bodi Assembly constituency. Considering the national importance of the proposal, the MoEF decided to take the proposal at the Central level as a special case — a category 8(a) project — and granted environmental clearance with 17 conditions.

NGT issues notice to BCCI, 9 States

The National Green Tribunal (NGT) issued notices to the Board of Control for Cricket in India and nine States on a petition alleging that water would be misused during the upcoming Indian Premier League matches. The petitioner further sought a ban on the tournament, citing wastage of water in the process of preparing the cricket pitches.

A bench, headed by judicial member Jawad Rahim, sought responses from the BCCI, the Ministry of Water Resources and nine States, including Delhi, West Bengal, Maharashtra, Karnataka and Telangana. The panel directed the respondents to file their replies within two weeks.

The plea filed by Alwar resident Haidar Ali read, "There is rampant misuse of water by some individuals and societies and organisations and on the other hand, in major parts of India, people are suffering from scarcity of drinking water. Lakhs of litres of water will be used for preparing the cricket stadium pitches for playing 60 matches, which is adversely affecting the ecosystem and overall ecology of a country already suffering from droughts."

Notice to Bengal over GI tag for 'Rosogolla'

The Geographical Indication (GI) Registry has issued a notice to the West Bengal State Food Processing and Horticulture Development Corporation, asking why the GI recognition given to 'BanglarRosogolla' not be withdrawn. Reacting to an application for rectification or removal filed by Ramesh Chandra Sahoo, chairperson of the Bhubaneswar-based Regional Development Trust, the GI Registry office in Chennai served this notice to West Bengal.

Questions documents

Through this petition, Mr. Sahoo had objected to the GI status procured by West Bengal for 'BanglarRosogolla' four months ago. He had also questioned the data pro-

vided by West Bengal for getting the GI tag.

He also said that Odisha was not given a chance to explain its stance when West Bengal applied for the GI status.

Odisha Small Industries Corporation applied for the GI tag for 'Odisha's Rasagola' on January 23 this year. The application includes historical evidence seeking to prove that the famous sweet was part of the offering in Sri Jagannath Temple of Puri at least five centuries ago.

"With the emergence of more and more historical evidences, it is proven that the rasagola had originated in Odisha as a special offering at the Sri Jagannath Temple of Puri. Later, its preparation technique had reached West Bengal and other parts of the country," said cultural researcher Asit Mohanty, who helped in collecting evidences for the 'Odisha's Rasagola' GI tag application.

A floating laboratory to save the famed Loktak Lake

Three days a week, four women in white lab coats traverse the Loktak Lake in a custombuilt motorboat, scooping flaskfuls of water for analysis. They record changes in the temperature, acidity, conductivity and dissolved-oxygen in the 300-sq km lake.

Rising urbanisation and land-use change over the years has seen the Loktak Lake, the largest in the northeast, become a dump yard for municipal waste.

Rajkumari Supriya, a researcher at the Institute of Biore-sources and Sustainable Development (IBSD), said she and her colleagues, all in their 20s, as part of their routine, first measure preliminary characteristic of the water on the boat and then follow it up with more analysis at their lab. "Over there, we calculate the biochemical oxygen demand, chemical oxygen demand, chloride test and nitrogen levels," she said.

'Silent threat'

Though the Loktak Lake is yet to see worrying levels of pollution, early signs suggest that there's needed to be vigilant.

"Everyone talks about carbon dioxide levels, but nitrogen pollution is a major, silent threat," said Dinabandhu Sahoo, director, IBSD and project head, "Already there are signs of calcium anomalies in some of the mollusc and other aquatic life in the lake." This is similar to the phenomenon of coral bleaching in oceans, where rising sea surface temperature cause organisms that live on corals to disengage, thereby killing the corals themselves. The model of a floating laboratory ties in with a larger initiative by the Centre's Department of Biotechnology (DBT) to monitor the health of aquatic systems in the northeast.

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aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

Last September, the DBT announced plans to have multiple boats cruising the 3,500-km Brahmaputra river and collecting water samples to track its health.

The health of the lake also affects the Phumdis, or the unique 'floating islands', on the lake. These islands, made of a mix of vegetation and soil, coalesce to form a thick mat that, for centuries, have hosted huts and fishing settlements. "We are studying the nutrient uptake of these vegetation and monitoring their health," said Mr. Sahoo. The pH level of the lake, as per measurements so far, varies from 6.8 to 7.2 (ideally it should be slightly below 7). "Studies of ocean acidification have shown that even a 0.1 increase can cause [harmful] decalcification," Mr. Sahoo said. "We shouldn't wait for the lake to hit the ICU before thinking of ways to save it."

Radar speed signs to slow down drivers

There are traffic police, armed with interceptors, to flag down motorists who drive over the speed limit. But that hasn't really helped. Recently, a head constable, who was on duty on NICE Road, was knocked down by a speeding vehicle.

The police are now planning to use technology that will appeal to drivers in the hope that they will slow down. LED display boards will be installed on the medians of key roads. These will display a vehicle's speed in real time against the permitted limit.

"These are called driver feedback systems that work on radar or Doppler technology. They register the speed of an approaching vehicle 50 metres away. This will be flashed to the driver on the display board," said R. Hithendra, Additional Commissioner of Police (Traffic).

So what if there are multiple vehicles? On high-speed corridors, it's rare to see multiple vehicles at a stretch, said Mr. Hithendra. "But in such cases, it will flash the highest speed."

The purpose of radar-speed signs is to make drivers aware that they are crossing the limit. They are used to slow the drivers down in many countries.

Traffic expert Prof. M.N. Srihari said this technology is commonly used on highways in Europe and the United States. Empirical evidence shows that displaying the speed of a vehicle against the speed limit will see drivers slowing down. "These are also called traffic calmers," said Mr. Srihari.

Traffic police officers concur. "When the real-time speed is shown to the drivers, they react by slowing down. Even

co-passengers in the vehicle will ask the driver to slow down. It's a psychological trigger that will work," said Mr. Hithendra.

50 units to be installed

The traffic police are all set to issue tenders for 50 such driver feedback systems, where each will have two radar systems for either lane. These will be put up in accident-prone zones on Outer Ring Road, the elevated expressway to KIA on Ballari Road, the elevated expressway to Electronics City, NICE corridor and Tumakuru Road, sources said.

Star molecule from IIT-M

It is a marvel of synthetic chemistry that today we can build molecules pretty much like we make up structures with building blocks. Using this method for their science at Dillip Kumar Chand's lab at the Department of Chemistry, Indian Institute of Technology Madras, researchers have made a molecule that looks like a five-pointed star with its tips truncated.

All you have to do to build the molecule is to get together the component molecules and ligands and shake them with a solvent in a "one-pot." Of course, the hard work is in knowing what components you will add to the solvent and in what measure. Prof. Chand's team calculated the structures using the density functional theory, to work out the architecture of the molecule they were building.

Designer molecules

Such designer molecules with cavities in them can be used for drug delivery. Prof. Chand explains: "Molecules having a cavity are used for binding the guest [molecule] and transporting the guest to another site." For example, binding a drug and delivering the drug. In building this molecule, the researchers introduce more than one cavity in a single molecule. This makes it more interesting.

In order to build the desired molecule, the team uses three components: One is palladium (II) which can bind to molecules at four places 90 degrees apart. The second is the molecule 4-4'-bipyridine which is like a rod that can bind at its two ends. And the last is the molecule 1,4-phenylenebis(methylene) diisonicotinate which is like a stick bent twice along its length and can bind to two molecules at its two ends. By throwing in five measures each of the three components, the team comes up with a star-shaped resultant molecule as shown in the picture.

The use of palladium (II) itself is unusual and new. Further, binding it to two different ligands has never been done before. Normally, using a rigid rod-like ligand would usually yield a square arrangement but in this case it yields a pentagonal star-like arrangement. "Since we an-



aspirantforum.com
Science and Tech.
The Crux of The Hindu
Vol. 13
News of Jan-Mar18

anticipated a pentagonal architecture, it excited us to put our full effort on the project. In nature there are many pentagonal structures whereas among chemicals, the pentagonal structure is very rare," says Prof. Chand. The team now aims to make different variations of this design and use the cavity for binding drug molecules and transport them to required sites. "Also, we want to utilise the related molecules in catalysis," he adds.

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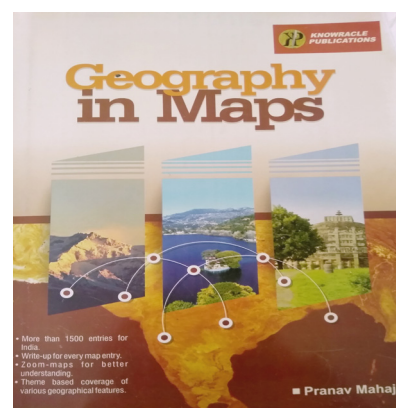
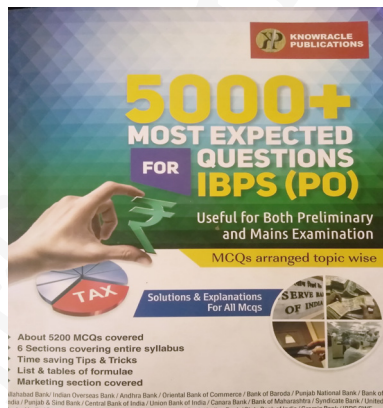
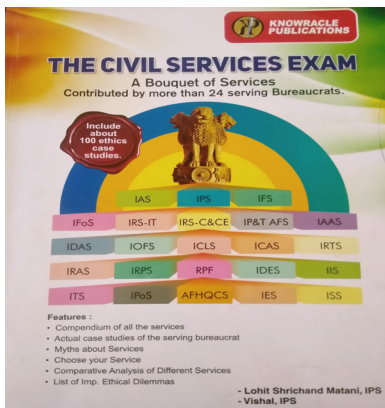
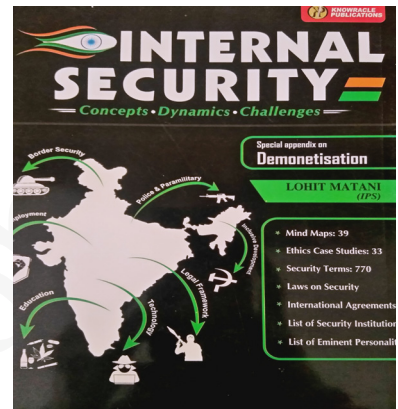
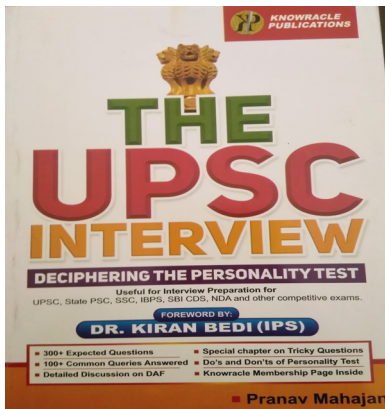
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aspirantforum.com
Science and Tech.
The Crux of The Hindu
 Vol. 13
 News of Jan-Mar18



Vol. 13 Jan-Mar

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