



Science Reporter

A CSIR Publication

May 2022 • ₹ 30/-

INDIA'S
S&T
MISSIONS

*Making India
Future Ready*

75
Azadi Ka
Amrit Mahotsav



FEATURES

Deep Ocean Mission
India Semiconductor Mission
Waste to Wealth Mission
Biodiversity & Health Mission
Electric Vehicles Mission
Quantum Frontier Mission
Digital India Mission
National Hydrogen Mission



9 EDITORIAL A Mission Mode Approach – Making India Future Ready Hasan Jawaid Khan

14 Diving to Newer Depths India's Deep Ocean Mission Set to Create New Landmarks

M. Ravichandran, Vijay Kumar,
G.A. Ramadass, Gopal Iyengar,
S. Ramesh, M. Ashokan, Bhavya
Khanna

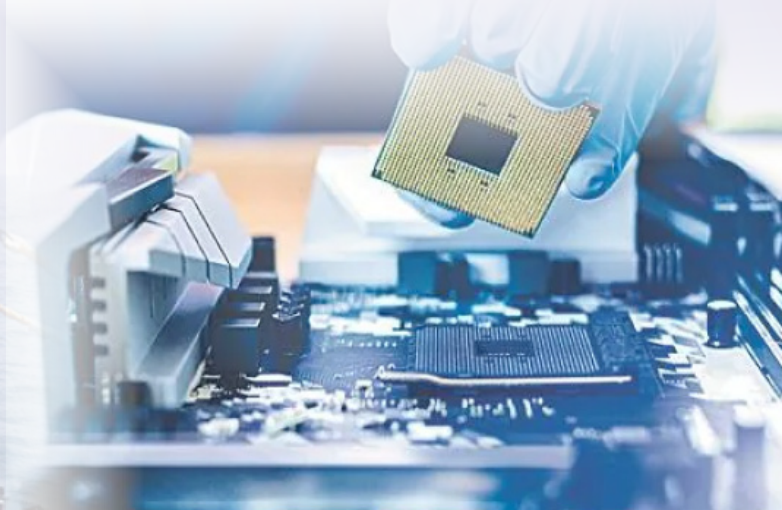
19 India Semiconductor Mission Boosting India's Semiconductor and Display Ecosystem

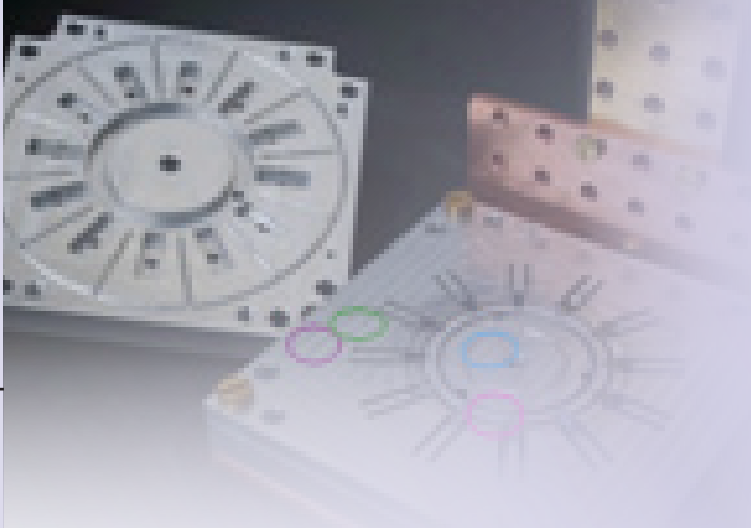
V.K. Saraswat

22 Waste to Wealth Mission The Goal – Zero Landfills Shailja Vaidya Gupta

26 National Mission on Biodiversity and Human Well-being Ketaki Bapat

28 Electric Vehicles Mission Leap Towards a Greener Future Sneha Malhotra, Preeti Banzal





38 **Quantum Frontier Mission** **Quantum Enabled Science & Technology (QuEST)**

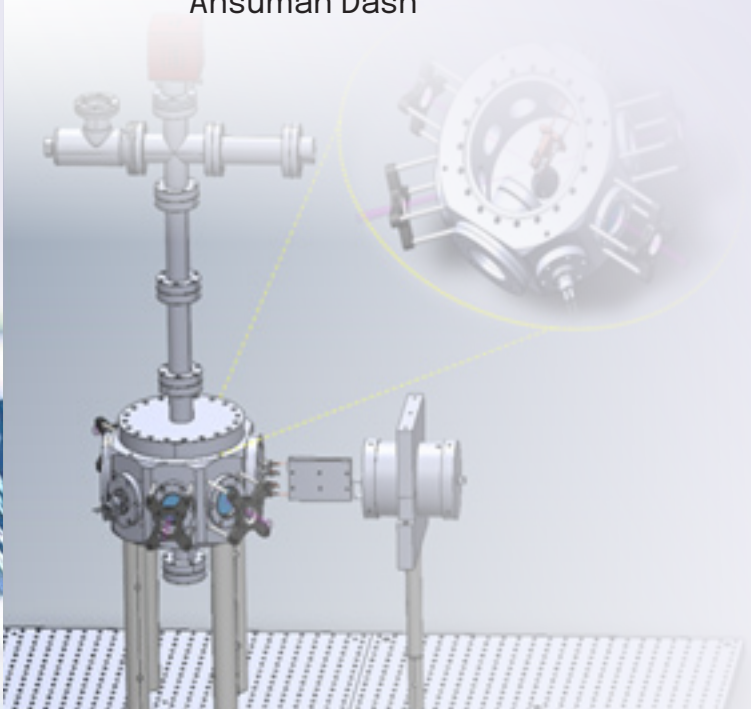
K.R. Murali Mohan, Rajeev Sharma

42 **Digital India Mission** **Catalysing Change, Accelerating National Development**

Siddhey Shinde, Juhi Jain

46 **National Hydrogen Mission** **Can Green Hydrogen be the doorway to sustainable energy transition?**

Ansuman Dash



32 **FEATURE** **Electrical Mobility: Gliding into the acceleration phase**

Anand Parthasarathy

48 **IN CONVERSATION** **“Resilience, perseverance and persistence are important in research”: Prof. Chennupati Jagadish**

Meher Wan

51 **SCIENCE FICTION** **2082**

Shruti M.

54 **CSIR – 80 YEARS OF IMPACT** **The HANSA – Two-seat Aircraft for Pilot Training**

R. Venkatesh

56 **Bharatiya Nirdeshak Dravya (BND) or Indian Reference Material: Ensuring reliability, comparability and quality**

Nahar Singh

Spectrum	10
Test Your Knowledge	58
Azadi Ka Amrit Mahotsav Science Quiz	60
Puzzle	62
Science Cartoons	64



DIRECTOR
Dr Ranjana Aggarwal

EDITOR
Hasan Jawaid Khan

ASSISTANT EDITOR
Sonali Nagar
Meher Wan

LAYOUT & DESIGN
Neeru Vijan
Manender Singh

PRODUCTION
Ashwani Kumar Brahmi
Arun Uniyal
Anil Kumar

BUSINESS DEVELOPMENT
Dr Mohammad Rais
Dr Kanika Malik

COVER DESIGN
Manender Singh



A Mission Mode Approach – Making India Future Ready

INDIA'S committed reliance on science and technology after the country's independence has paid rich dividends. S&T helped transform India from a country with a shattered economy & no sound industrial base, abysmally low agricultural production & almost non-existent health services to a country that has risen to the 46th position among the top 50 innovative economies globally as per the Global Innovation Index (GII). We rank third among the most attractive investment destinations for technology transactions in the world. India remains among the top three countries in scientific publications as per NSF database, and has also reached third position in terms of number of PhDs, size of Higher Education System and number of Startups. India is also positioned as one of the top five nations in space exploration.

As part of the “Azadi ka Amrit Mahotsav” celebrations announced by Prime Minister Shri Narendra Modi in March 2021 to commemorate 75 years of the country's Independence, *Science Reporter* has so far brought out two special focused issues to showcase a snapshot of the achievements of the Indian scientific community and scientific institutions during the past more than seven decades.

The August 2021 issue focused on “75 Years of India's S&T Journey”, with India's top science leaders and science administrators writing about the immense S&T contributions in varied fields and sectors such as biotechnology, defence, space, agriculture, health, and atomic energy. *Science Reporter's* November 2021 issue focused on some selected International Mega Science projects where India is an integral part – including LIGO, LHC-CERN, ITER, SKA, INO, FAIR & TMT – with experts at the helm of these projects writing about the immense and critical contributions of the Indian scientific community to the global multi-institutional projects with highly ambitious goals.

Today, Indian scientists and technologists are working on emerging technologies such as Nanotechnology, Artificial Intelligence and Robotics, Augmented and Virtual Reality, Internet of Things and so on. And so, once again, as part of the “Azadi ka Amrit Mahotsav” special issue series, and also to commemorate India's National Technology Day 2022 (11 May), *Science Reporter* brings for its readers a focused issue on some of India's recent S&T Missions addressing specific issues related to electric vehicles, semiconductors, hydrogen energy, deep ocean exploration, biodiversity & health, waste management, quantum computing, and making India digital.

We do hope our readers are sufficiently enlightened about these major S&T missions that India has embarked upon.

Hasan Jawaid Khan



Science Reporter is published monthly by the National Institute of Science Communication and Policy Research (NIScPR), CSIR, Dr K S Krishnan Marg, New Delhi-110 012. NIScPR assumes no responsibility for statements and opinions advanced by the authors or for any claims made in the advertisements published in *Science Reporter*.

For Editorial Queries: Ph.: 91-011-25848702; Email: sr@niscpr.res.in; Fax: 91-011-25847062

For Sales & Subscription Related Queries: Ph.: 91-011-25841647, EPABX: 011-25846301 Extn. 289; Email: psmsupport@niscpr.res.in

For Advertisement Related Queries: Ph.: 91-011-25843359, EPABX: 011-25846301 Extn. 291; Email: psmsupport@niscpr.res.in;

Website: <http://www.niscpr.res.in>

Subscription: Inland: 1 yr: Rs 300/-; 2 yrs: Rs 570/-; 3 yrs: Rs 810/- Foreign: 1 yr (Air Mail): US \$ 90 (Annual)

© National Institute of Science Communication and Policy Research (NIScPR)

Paper discs that can pick up hydrogen peroxide

RESearchers at the Indian Institute of Science (IISc) have developed a paper-based sensor for detecting even tiny volumes of hydrogen peroxide. This chemical is used widely in household and healthcare products like hand sanitiser as a disinfectant, in rocket fuel as a propellant, and is also found in biological cells.

The technique they used involved preparing a gel from a solution containing a specially designed molecule, treated with a liquid that has hydrogen peroxide, and air-drying them on a thin paper disc about 0.45 cm in diameter. The paper disc emits green light when placed under a UV lamp, only in the presence of hydrogen peroxide. The intensity of the light was found to be directly proportional to the concentration of hydrogen peroxide.

"You can actually visualise this green emission (photoluminescence) with the naked eye. You don't need any sophisticated instruments. All you need is a simple UV light source," explains Arnab Dutta, PhD

student in the Department of Organic Chemistry and the first author of the study published in *ACS Sensors*.

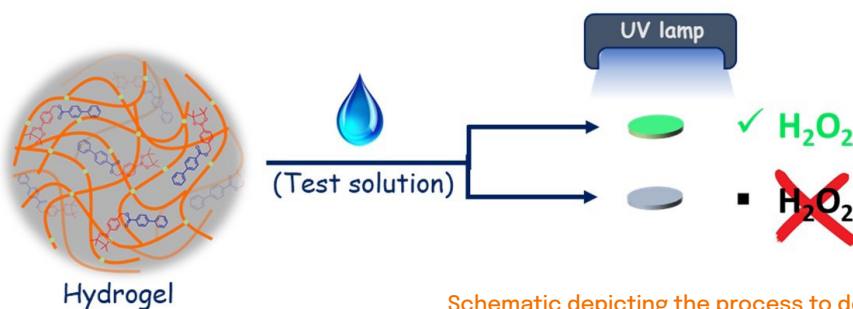
Because the paper disc is low-cost, biodegradable and easy to use, it could serve as a powerful tool in low-resource settings, even for testing biological fluids like blood. Detecting hydrogen peroxide efficiently is also crucial in other fields; peroxide-based explosives, for example, can be traced using hydrogen peroxide which is sometimes used as a starting material.

When the researchers used their technique to randomly test five different hand sanitiser brands, they found that only three of them contained the level of hydrogen peroxide mandated by the World Health Organisation – 0.125%. A fourth appeared to have much lower than 0.125% and one had almost zero hydrogen peroxide.

"Hydrogen peroxide can be detected on a larger scale using titration and other experiments, but those are cumbersome and require training. This method is easy because of its simplicity," says Uday Maitra, Professor in the Department of Organic Chemistry and senior author of the study.

Currently, the team is working on cutting down the reaction time; it takes a bit longer if the concentration of hydrogen peroxide is lower.

Source: IISc Press Release



Schematic depicting the process to detect hydrogen peroxide (Credit: Arnab Dutta)

IIT Delhi startup develops highly effective antiviral fabric

AFTER three years of rigorous research & development, Fabiosys Innovations, a deep-tech healthcare startup incubated at IIT Delhi, has developed an affordable high-performance medical textile called Fabium, which destroys more than 99% of bacteria and viruses within 30 minutes.

Ordinary antimicrobial fabric products available in the market inhibit microbes in 24 hours with unsatisfactory efficiency. This period of 24 hours makes those antimicrobial fabric products impractical to be used in everyday life because a typical bacterium doubles itself in around 20-30 minutes.

Fabium is developed using Hi-PAT technology, which makes it highly effective against bacteria, viruses, and fungi. It starts working within seconds of contact with the pathogens and destroys them within 30 minutes.

Large-scale manufacturing of Fabium requires passing the raw cotton fabric through a set of proprietary chemical formulations while using the standard textile processing machinery, which is commonly available in the Indian textile industry.

The team has successfully completed large-scale manufacturing trials in collaboration with a textile industry partner in the Delhi-NCR region to ensure

IIT Mandi researchers produce new photocatalysts that convert plastics to hydrogen and other useful products

INDIAN Institute of Technology Mandi researchers have developed a method that can transform plastic into hydrogen when exposed to light. Fuelled by the need to prevent runaway plastic pollution, IIT Mandi researchers are developing methods that can transform plastic into useful chemicals. The findings from the work have been published in the *Journal of Environmental Chemical Engineering*.

Dr Prem Felix Siril, Professor, School of Basic Sciences, IIT Mandi, says, “The ideal path to effective annihilation of plastics is to degrade them into useful chemicals. The generation of hydrogen from plastics is particularly useful because the gas is considered the most practical non-polluting fuel of the future.”

The researchers have developed a catalyst that can efficiently convert plastics into hydrogen and other useful chemicals when exposed to light. Catalysts are

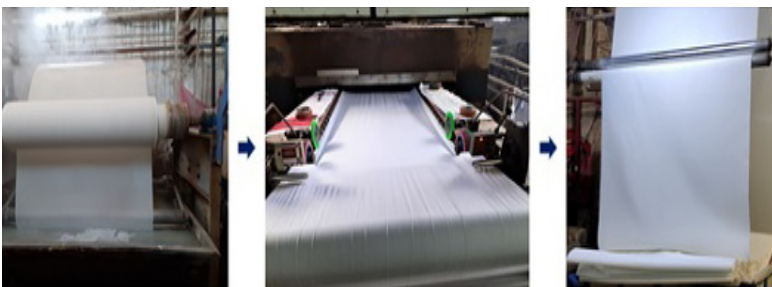
substances that drive otherwise difficult or impossible reactions and when they are activated by light, they are called photocatalysts. The IIT Mandi photocatalyst combines iron oxide in the form of nanoparticles with a conducting polymer — polypyrrole. The catalyst is activated with sunlight.

The researchers found there was 100% degradation within four hours when they used a catalyst in which about 4% weight of iron oxide was present in the polypyrrole matrix. The researchers then tested this catalyst on polylactic acid (PLA), a plastic that is extensively used in food packaging, textiles, medical articles and cosmetics. The team found that hydrogen was evolved during the breakdown of PLA when the catalyst was exposed to visible light.

“While the generation of hydrogen is good in itself, we are even more excited about the absence of carbon dioxide,” said Dr Prem Felix Siril. While most other photocatalysts that have been developed for hydrogen generation from plastics release greenhouse gas as a by-product, the IIT Mandi catalyst did not but instead co-produced useful chemicals such as lactic acid, formic acid and acetic acid.

The use of the photocatalyst does not stop with plastic treatment. It can also be used for photoreforming of food waste and other biomass and also for breaking down pollutants in water. The interesting heterojunction properties of nano iron oxide and polypyrrole offer scope for the development of new catalysts for energy production and environmental applications.

Source: IIT Mandi Press Release



that large-scale fabric manufacturing can be done while maintaining its high efficiency and affordability.

Fabium can be made with any kind of fabric — natural or synthetic; woven, non-woven, or knitted. One of the major USPs of Fabium is its natural colour, which is 100% white, making it suitable for further dyeing, printing, embroidery, and other kinds of designing.

“The affordability of Fabium is due to its technology rather than cheap labour cost. Market research done by teamFabiosys indicates that cost-effective novel chemical formulation and unique textile processing technology make Fabium a comparatively affordable antiviral fabric. We are receiving encouraging responses from the industry for manufacturing & distribution of Fabium products,” said Yatee Gupta, Founder, Fabiosys Innovations.

The fabric is free from formaldehyde & metal nanoparticles, which cause toxicity & irritation to the human body. The material is rigorously tested as per ASTM D737 Standard for air permeability, which shows that the Fabium is almost as breathable as regular fabrics, making it very useful in applications like masks & coveralls (PPE), where breathability is almost always an issue.

Source: India Science Wire

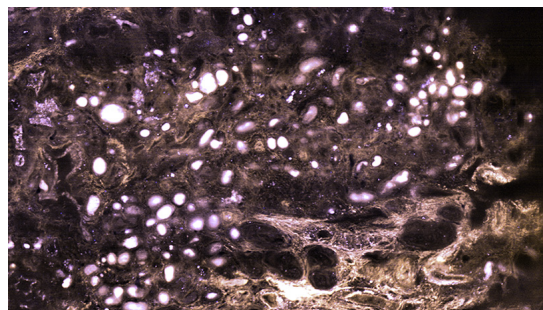
New technology could make biopsies a thing of the past

A Columbia Engineering team from Columbia University, New York, has developed a technology that could replace conventional biopsies and histology with real-time imaging within the living body. Described in a new paper published in *Nature Biomedical Engineering*, MediSCAPE (SCAPE — Swept Confocally Aligned Planar Excitation microscopy) is a high-speed 3D microscope capable of capturing images of tissue structures that could guide surgeons to navigate tumours and their boundaries without needing to remove tissues and wait for pathology results.

“The way that biopsy samples are processed hasn’t changed in 100 years; they are cut out, fixed, embedded, sliced, stained with dyes, positioned on a glass slide, and viewed by a pathologist using a simple microscope. This is why it can take days to hear news back about your diagnosis after a biopsy,” says Elizabeth Hillman, professor of biomedical engineering and radiology at Columbia University and senior author of the study.

Hillman’s group dreamed of a bold alternative, wondering whether they could capture images of the tissue while it is still within the body. “Such a technology could give a doctor real-time feedback about what type of tissue they are looking at without the long wait,” she explains. “This instant answer would let them make informed decisions about how best to cut out a tumour and ensure there is none left behind.”

Another major benefit of the approach is that cutting tissue out, just to figure out what it is, is a hard



decision for doctors, especially for precious tissues such as the brain, spinal cord, nerves, the eye, and areas of the face. This means that doctors can miss important areas of the disease. “Because we can image the living tissue, without cutting it out, we hope that MediSCAPE will make those decisions a thing of the past,” says Hillman.

One of the first tissues we looked at was fresh mouse kidney, and we were stunned to see gorgeous structures that looked a lot like what you get with standard histology,” says Kripa Patel, a recent PhD graduate from the Hillman lab and lead author of the study. “Most importantly, we didn’t add any dyes to the mouse — everything we saw was natural fluorescence in the tissue that is usually too weak to see. Our microscope is so efficient that we could see these weak signals well, even though we were also imaging whole 3D volumes at speeds fast enough to rove around in real-time, scanning different areas of the tissue as if we were holding a flashlight.”

The team demonstrated the power of MediSCAPE for a wide range of applications, from analysis of pancreatic cancer in a mouse to Coley’s interest in the non-destructive, rapid evaluation of human transplant organs such as kidneys. Coley helped the team get fresh samples from human kidneys to prove that MediSCAPE could see telltale signs of kidney disease that matched well with conventional histology images.

Source: Columbia University Press Release

Human skin can identify subtle changes in chemistry, finds study

RECENT research has shown that human touch can tell minimal differences in the chemical composition of a surface. The research led by Charles Dhong, a material scientist at the University of Delaware (UD), was presented at the American Chemical Society’s national meeting held in San Diego. The researchers anticipate that the discovery could open new avenues toward controlling the perception of touch and utilising it in applications like virtual reality.

The rapidly emerging technology has witnessed growing interest in developing systems that incorporate human senses. These senses, specially sight and sound, find applications in smartphone screens, computer monitors, virtual reality headsets, and audio devices. Tactile perception, the ability to perceive sensation through touch, is a complex human sensory system involving various sensations, like pain, temperature, and body awareness. Due to this complexity, touch remains perhaps the most underexplored sense in technological applications. The team at UD has found a way around this roadblock by demonstrating that humans can use their fingers to perceive the faintest of chemical changes in a surface, like the substitution of a nitrogen atom for a carbon atom.

As reported in a column published by UD, Prof. Dhong said, “When you touch an object, you’re feeling its surface, and you can change how it feels by changing the friction between that surface and your finger. That’s where the chemistry comes in...We think

Scientists find traces of plastic in human blood

PLASTIC is bad for the planet. But now, a first-of-its-kind study has revealed evidence of tiny plastic particles in human blood too. The study conducted by a team of scientists from the Netherlands says that these plastic particles of size less than five millimetres can travel through the bloodstream and may even house certain body organs.

According to a United Nations Environment Programme report, every year the world generates around 300 million tonnes of plastic waste. Similarly, as per the World Economic Forum, 1.3 billion tonnes of plastic waste will be there in the environment by 2040. As the world grapples with the substantial surge in the plastic pollution crisis and the worsening global public health, this breakthrough study is a way forward in gaining an insight into how hazardous exposure to plastic in humans is.

In a news release by the Vrije Universiteit (VU) Amsterdam, the co-author of the paper, Marja Lamoree, analytical chemist and Professor, VU said that "This dataset is the first of its kind and must be expanded to gain insight into how widespread plastic pollution is in the bodies of humans, and how harmful that may be. With this insight, we can determine whether exposure to plastic particles poses a threat to public health."

In the study, scientists obtained and analysed blood samples from 22 healthy volunteers. The team found plastic particles in 17 out of 22 samples, half of which contained PET plastic which is widely used in

the packaging of foods and beverages like soft drinks and juices. The test also detected the presence of polystyrene and polyethylene in 36% and 23% of the samples, respectively. Polystyrene is primarily used by the food service and food packaging industry, while polyethylene, the most commonly used plastic, is present in various everyday products, including grocery bags, housewares, squeeze bottles, and toys.

The concentrations of plastic particles reported in the study are the sum of all potential exposure routes, such as the living environment, personal care products like lip gloss and toothpaste, dental polymers, fragments of polymeric implants, polymeric drug delivery nanoparticles, and tattoo ink residues. The team found that the mean of the sum quantifiable concentration of plastic particles accounted for 1.6 micrograms in one millilitre of blood. Although this concentration of plastic particles observed was low, even a hint of microplastics in the blood is a matter of grave concern.

The study indicates that some of the particles of plastic with which people interact can be bioavailable, and their removal from the body is at a slow rate than their rate of absorption into the blood.

In light of the study findings, the investigators are worried about the fact that microplastics could be detrimental to human cells. However, the study has sparked plenty of related questions that are yet to be answered. The team believes that further research should help understand the impact of plastics on the human body and determine whether these particles are there in the plasma or carried by some specific cell types.

The findings recently appeared in the journal *Environment International*.

Contributed by Ms Tanumita Misra, pursuing MSc (S&T Communication) at AcSIR, CSIR-NIScPR

materials chemistry could open the door to recreating more nuanced sensations, whether you're designing a product to feel a certain way or creating feedback devices for virtual reality."

The fast growing haptic technology uses tactile sensations to stimulate touch in a user experience. A very common example of haptics is vibration in our mobile phones or game controllers. Most of the currently popular haptic devices use physical features like vibrations or mechanical actuations. Some wearable devices do use organic materials to create haptic sensations but they too produce tactile sensations by creating a physical bump or moving a pin. The previous experiments by Dhong's team demonstrated how people could use their fingers to differentiate one-molecule-thick layers of a silicon-containing compound, silane, with undetectable differences in smoothness. They could do so because of indistinct changes in friction caused by chemical differences, including the replacement of one atom within each silane molecule with another.

The recent work of Dhong's team, presented at the San Diego meet, revolved around polymers having similar formulas and molecular weights. However, they differed in their degree of crystallinity which defines the alignment of chain-like molecules with one another. The experiments revealed that the human sense of touch could also differentiate between polymers only on the basis of alterations in friction. And these changes in the friction arose out of slight modifications in the crystallinity of the molecules.

As per the findings published in *Soft Matter* (<https://pubs.rsc.org/en/content/articlelanding/2021/sm/d1sm00451d>) by the Royal Society of Chemistry, the researchers foresee the potential of creating tactile differences through chemical features instead of physical in designing new systems. These systems could enable more accurate tactile sensations for human-machine interfaces.

Contributed by Ms Tanumita Misra, pursuing MSc (S&T Communication) at AcSIR, CSIR-NIScPR

Diving to Newer Depths



India's Deep Ocean Mission Set To Create New Landmarks

THE Deep Ocean Mission — India's flagship programme to explore the deep oceans — was approved by the Cabinet in June 2021 with a budget outlay of Rs 4,077 crores over five years. To be chiefly coordinated and implemented by the Ministry of Earth Sciences, the Deep Ocean Mission aims to expand India's deep-sea scientific research, activities, and expertise.

Aligned with the vision of the Hon'ble Prime Minister, Shri Narendra Modi, the Deep Ocean Mission will provide a big boost to India's blue economy by aiding the development of infrastructure, trade, tourism, revenue, and opportunities. The Deep Ocean Mission is identified amongst the nine missions under the PM-STIAC (Science, Technology and Innovation Advisory Council) aimed to develop a futuristic roadmap for the holistic progress of our country.

In October 2021, with the launch of *Samudryaan* under the Deep Ocean Mission by the Hon'ble Union Minister, Dr Jitendra Singh, there is now more mettle to India's strong commitment to making the Deep Ocean Mission highly successful.

Samudryaan ('Samudra' meaning Ocean and 'yaan' meaning vehicle) is India's first manned mission to reach the ocean bed at 6,000 meters below the water surface. It aims to onboard a three-membered crew and scientific equipment in Matsya 6000, which is an indigenously developed underwater vehicle for deep-sea mining and exploration in the Central Indian Ocean. 'Matsya' is the Sanskrit word meaning Fish, which signifies that the indigenously-developed Indian underwater vehicle will exhibit significant endurance and resilience.

The Deep Ocean Mission encompasses a set of six ambitious focus areas with an overarching aim to explore the deep oceans and sustainably harness marine resources for advances in science, technology, and engineering for societal benefit. Almost 90 per cent of the world's oceans remain unexplored to date. The Deep Ocean Mission, which will enhance exploration and harnessing resources, is envisaged to be a source of new knowledge, valuable materials including chemicals, drugs, and minerals, several undiscovered species, and much more. Moreover, the wisdom emanating from the Deep

Dr M. Ravichandran

Secretary, Ministry of Earth Sciences (MoES)

Dr Vijay Kumar

Scientist G-Adviser & Programme Head, Deep Ocean Mission, MoES Hq

Dr G.A. Ramadass

Scientist G-Adviser and Director, National Institute of Ocean Technology (NIOT), Chennai

Dr Gopal Iyengar

Scientist G-Adviser, MoES Hq

Dr S. Ramesh

Scientist G-Adviser, NIOT

Dr M. Ashokan

Scientist D, MoES Hq

Dr Bhavya Khanna

Scientist D, MoES Hq

Ocean Mission activities would also feed into ocean-related issues of national and international importance, such as improving marine and maritime economy, addressing climate change and pollution, and enhancing sustainable use of ocean resources.

The Ministry of Earth Sciences (MoES), erstwhile Department of Ocean Development established in 1982, is the nodal Ministry to implement the Deep Ocean Mission. MoES is a network of ten institutions (three attached offices, five autonomous institutes, and two sub-ordinate offices) spread across the country, with headquarters in New Delhi. Deep Ocean Mission is in accord

with the mandate of MoES to provide services of weather, climate, Ocean and coastal state, hydrology, seismology, and natural hazards; explore and harness marine living and non-living resources sustainably; explore the three poles of the Earth (the Arctic, Antarctic and Himalayas); and develop ocean technology for exploration of oceanic resources and societal applications.

Focus Areas

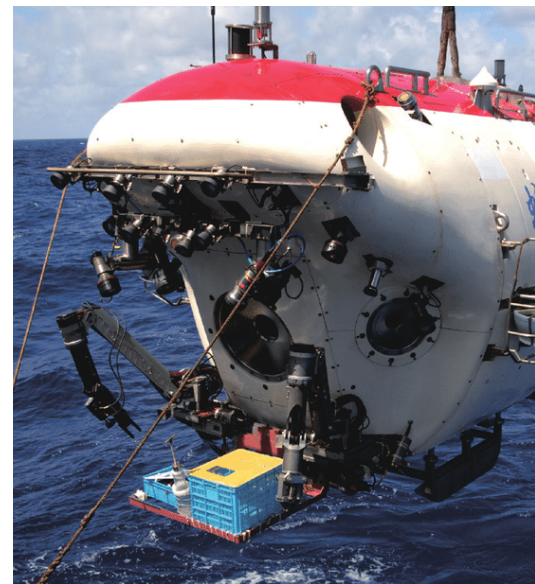
The six focus areas of activities planned under the Deep Ocean Mission are as follows.

1. Advanced technologies for deep-sea mining, manned submersible, and underwater robotics

India has been allotted an area of almost 75,000 square kilometres in the Central Indian Ocean Basin and another 10,000 square kilometres in the Mid-Ocean ridge (around 25° S in the Indian Ocean) by the International Seabed Authority, where most of the activities as part of the Deep Ocean Mission will be executed. These areas are rich sources of polymetallic nodules and sulphides. Polymetallic nodules and sulphides deliver metals such as Copper, Nickel, Cobalt, Molybdenum, Vanadium, Titanium, Platinum, and Rhodium, etc. that are extremely valuable and industrially useful. It is estimated that the value of extracted polymetallic nodules from the Central Indian Ocean basin as part of the Deep Ocean Mission will be to the tune of about 100 billion dollars, which would be a big boost to the Indian economy.

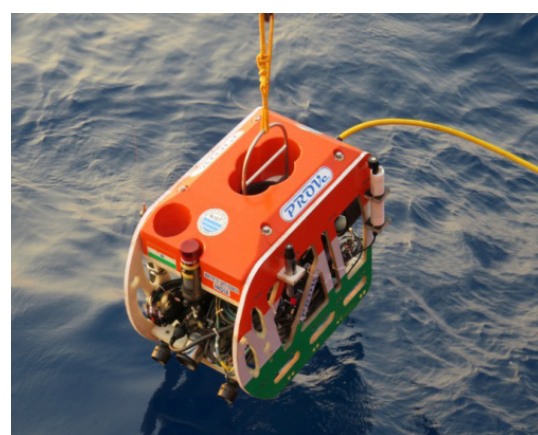
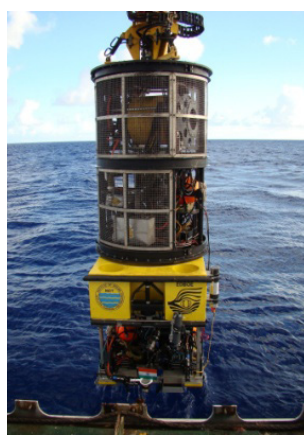


Launch of the *Samudryaan*, India's first manned deep-sea mission, under the Deep Ocean Mission, by the Hon'ble Union Minister, Dr Jitendra Singh, in October 2021, with Dr M. Ravichandran, Secretary, MoES (second from left).
(Courtesy: Press Information Bureau)



Manned submersibles Alvin of USA (up left), Jiaolong of China (up centre), and MIR 6000 of Russia (up right), Nautilie of France (below left) and Shinkai of Japan (below right).

Picture courtesy: Google Images.



Coastal research vessels (CRVs) named Sagar Tara (up left) and Sagar Anveshika (up right), Autonomous Underwater Vehicle (below left), Remotely Operated Vehicle (below centre), and Shallow water Remotely Operated Vehicle (below right), developed and deployed by the National Institute of Ocean Technology (NIOT), Chennai, under MoES for ocean research. (Picture courtesy: NIOT)

To achieve these objectives, India will expand its capacity to build, maintain, and operate more autonomous underwater vehicles, remotely operated vehicles, oceanographic research vessels, deep-sea crawlers, subsea drills, and similar deep-sea instruments.

Most importantly, India will develop a manned submersible that can carry up to three crew members to a depth of about six kilometres below the sea surface. The six-kilometre depth is set to execute mining at the Central Indian Ocean Basin location allocated to India by the United Nations (UN).

The indigenously developed manned submersible (named Matsya 6000) will combine the properties of both an autonomous underwater vehicle and a remotely operated vehicle. It will be a titanium alloy personnel sphere of about 2.1 metres in diameter with an

endurance of 12 hours and an additional 96 hours during emergency.

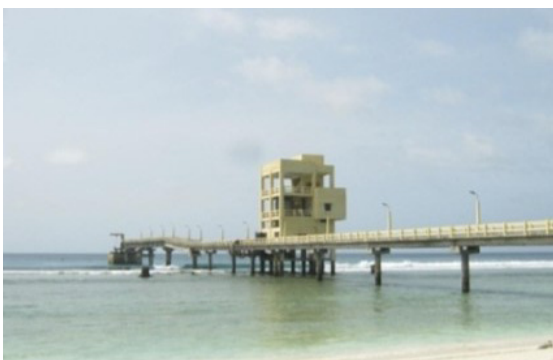
The metal with which Matsya is made, Titanium, is an industrially valuable, low density, high strength, and corrosion-resistant metal that will impart desirable properties to Matsya. The 6,000 meters depth would be a significant achievement, considering that the most advanced submarines reach a depth of only about 500 meters. With such advancement of technology, India will join the league of countries like France, Japan, China, Korea, Russia, and Germany. Matsya 6000 will be ready for qualification trials by December 2024.

The National Institute of Ocean Technology (NIOT), Chennai, an autonomous institute under the MoES, is entrusted with developing deep-sea technologies for India, such as for

deep-sea mining, manned submersible, and underwater robotics, and ensuring that they become operational and industrially viable.

2. Energy and freshwater from the Ocean

The upper layers of ocean water are warmer than the deep sea. This vertical thermal or heat gradient in oceans can be a renewable and green energy source and can be utilised for several purposes, including converting salty seawater to potable and clean water. Many remote locations in India are either not connected to the grid or experience frequent power cuts. For instance, the islands of Lakshadweep and Andaman are primarily powered by diesel generators, which is polluting and highly inefficient. For such issues, energy from oceans can be a big game-



Low-Temperature Thermal Desalination (LTTD) plants in Kavaratti (above) and Agati (below) islands in Lakshadweep generate nearly one lakh litres of fresh water from seawater per day.

changer. In addition to the thermal gradient in ocean waters, waves, winds, tides, and currents can also be used to harness energy.

A technology known as OTEC (Ocean Thermal Energy Conversion) helps generate power using the thermal gradient in ocean water. OTEC energy is entirely green, renewable, and sustainable. Under the Deep Ocean Mission, the Ministry of Earth Sciences, through the National Institute of Ocean Technology, Chennai, will carry out studies and detailed engineering design for offshore OTEC-powered desalination plant.

When integrated with another technology called LTTD (Low-Temperature Thermal Desalination), OTEC helps generate fresh potable water from ocean water. Three LTTD plants were set up by the Ministry of Earth Sciences, one each in three islands of Lakshadweep (Kavaratti, Agati, and Minicoy) since 2011. Each of these plants generates nearly one lakh litres of freshwater per day. This regular supply of clean water has helped improve the quality of life of the islanders.

LTTD plants in six more islands (Amini, Androth, Chetlat, Kadamat,

Kalpeni and Kiltan) are now on the anvil. In the future, MoES will establish additional OTEC-LTTD plants in several offshore locations and islands. This would be a boon for locals and coastal dwellers who constitute a significant workforce of our country.

3. Ocean climate change advisory services

The UN has declared 2021-2030 the Decade of Ocean Science for Sustainable Development. This emphasises the importance of oceans for Earth's sustenance and modulating processes to maintain life. Reports suggest that the Earth is already facing the brunt of climate change with irreversible effects. It is known that sea levels may rise, followed by the inundation of low-lying areas, increased flooding due to extreme weather events (like storm surges, cyclones, tsunamis, etc.) and erosion of beaches deltas and islands.

Under the Deep Ocean Mission, several activities and research projects will be executed to measure multiple ocean-related parameters like temperature, salinity and currents at various depths, wave, biogeochemical variables, etc., to understand and document changes in sea level, waves, cyclone intensity and frequency, and associated storm surges. Deep Ocean observations proposed under the mission will provide more insights into the role of Oceans in regulating global warming and climate change.

In collaboration with institutes and Universities, the Ministry of Earth Sciences will develop models to accurately simulate and forecast extreme weather and ocean events such as cyclones, storm surges, wind waves, and changes in sea level in a timely and user-friendly manner to stakeholders and the public to enable them with a better decision-making process.

4. Exploring and conserving deep-sea biodiversity

It is estimated that marine biodiversity far exceeds the diversity of life forms on land. Such expansive biodiversity

brings avenues for harnessing novel biomolecules having environmental, industrial, and biomedical applications.

The Deep Ocean Mission aims to explore, decipher, and discover the vast deep-sea fauna (animal diversity) and flora (plant diversity) in seamounts in the Indian Ocean. This programme can potentially lead to several innovations in both products and processes.

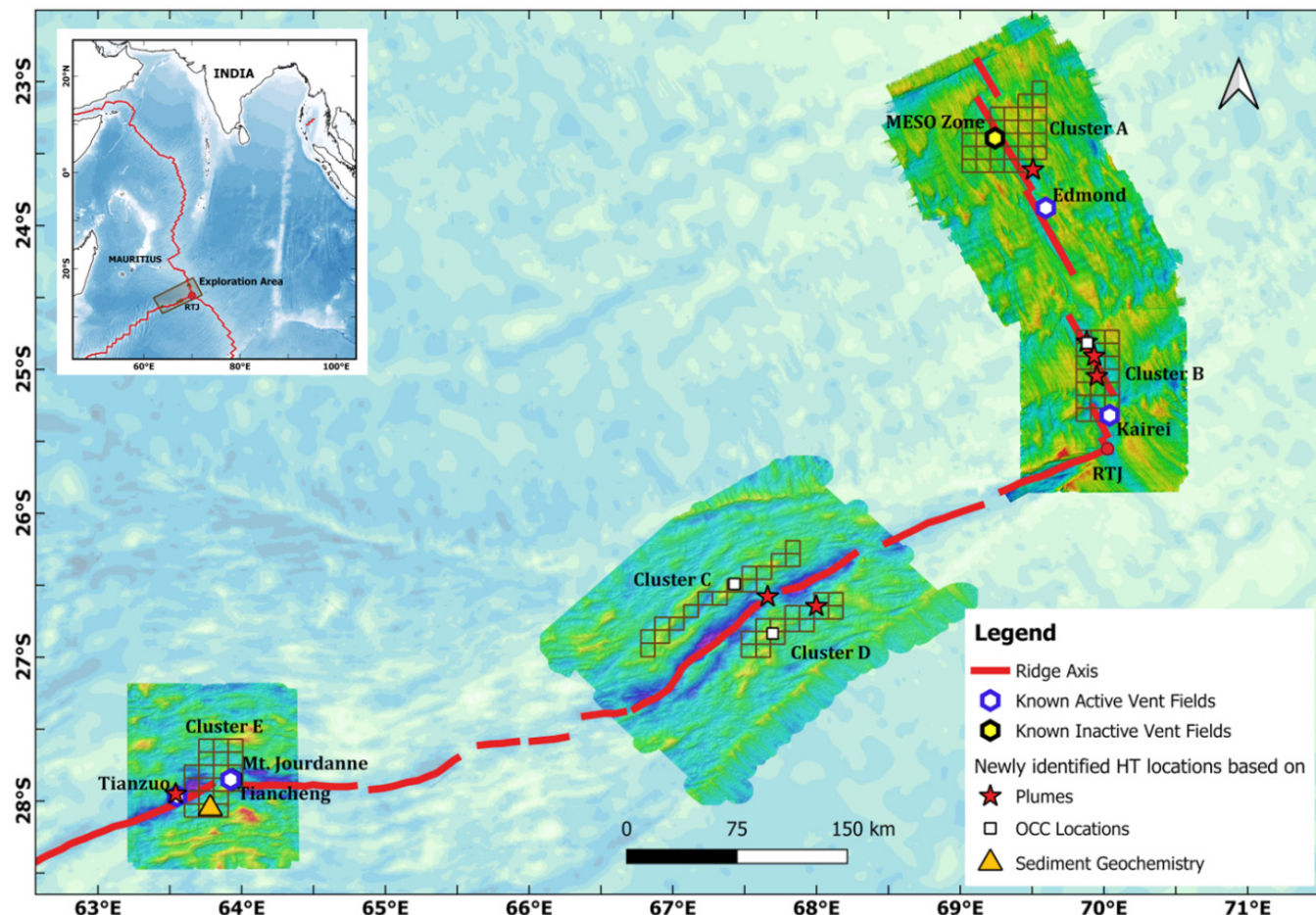
It is planned to execute this programme in close collaboration with the Department of Biotechnology, under the Ministry of Science and Technology, especially for advanced genome-related studies. Under this focus area, a DNA bank of deep-sea organisms will be established that will help enhance knowledge in marine biotechnology, taxonomy, genomics, etc. It would also fuel innovations and entrepreneurship.

In the future, activities under exploring and conserving deep-sea biodiversity of the Deep Ocean Mission will mark India as a trans-national and regional hub for marine biology and biotechnological know-how and advances.

5. Deep ocean survey and exploration

In the 1980s, India had conducted a deep ocean survey of about 1.5 lakh square kilometres in the Indian Ocean and submitted detailed and meticulous scientific reports to the international community. As a result, the UN allotted a vast, nearly 75,000 sq km of area in the Central Indian Ocean Basin to India in 2002 for deep ocean survey and exploration for polymetallic nodules. Under the Deep Ocean Mission, India plans to run and expand deep ocean survey and exploration in full swing.

In 2016, India signed a 15-year contract with the International Seabed Authority for exploring hydrothermal mineral deposits in the Indian Ocean ridges. It will help our country establish a solid footing in international waters and yield new knowledge of valuable minerals and resources that can be extracted as future alternatives



Area allocated to India by International Seabed Authority for exploration of polymetallic sulphides.
(Courtesy: National Centre for Polar and Ocean Research)

to land resources for global metal supply. It would also contribute to national revenue to expand India's blue economy.

The prime task is to explore and identify potential sites of multi-metal Hydrothermal sulphides mineralisation along the Indian Ocean mid-oceanic regions, hunting a few square meter vent areas in the vast Ocean at a depth of 3-4 km!

Deep ocean survey and exploration will require India to acquire new research vessels to launch advanced underwater robotics such as Autonomous Underwater Vehicles, Remotely Operated Vehicles, and deep-sea crawlers. These advanced new research vessels will be used for undertaking physical, chemical, geological, and geophysical ocean observations and exploration, apart from scientific investigations in the Ocean. The research vessels would be built in an Indian shipyard under the 'Atmanirbhar Bharat' vision and would create employment opportunities.

6. Advanced Marine Station for Ocean Biology in India

Under the Deep Ocean Mission it is also planned to set up an Advanced Marine Station for Ocean Biology in India. It is envisaged as a hub-and-spokes model and will help the Deep Ocean Mission to strengthen its networking with various organisations across research institutes for marine sciences within India and globally.

The Station will harbour a comprehensive set of technological platforms and know-how, which can be used as reference and training instruments, as well as establishing a commercial incubator/ accelerator. The translation of applied research into marketable products will be strongly encouraged through interactions with industries as well as through the hosting of incubator facilities for ocean science entrepreneurs. There will be a focus on capacity building which can be accomplished by developing education programmes at the masters and graduate levels.

At the international level, collaborative activities in research and teaching will be established with leading marine stations in France through an exchange of experts in research and education, shared use of knowledge, resources, expertise, equipment and technology. Several international scientific conferences and exchange programmes will be hosted. The Pacific Ocean-Indian Ocean-Arabian Sea rim countries (Japan, Fiji, Seychelles, Mauritius, Maldives and Tanzania) and other nations will partner with India in various capacities.

The Advanced Marine Station for Ocean Biology would make India a world leader of knowledge and innovations in ocean sciences.

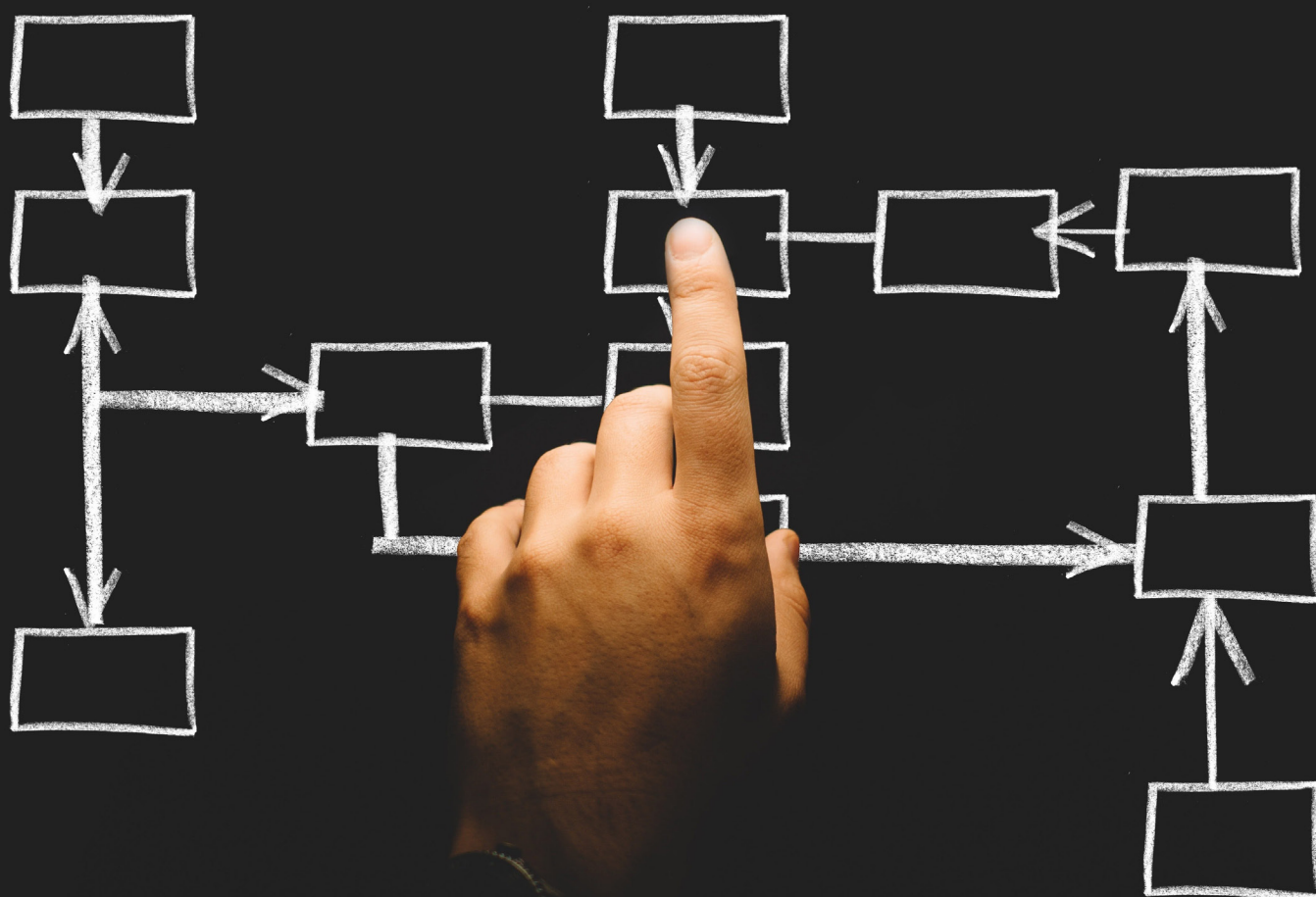
For further correspondence:

Dr Vijay Kumar, Program Head, Deep Ocean Mission (vijay.kumar66@nic.in, 011-24669518).

India Semiconductor Mission

Boosting India's
Semiconductor
and Display
Ecosystem

Dr V.K. Saraswat
Member, NITI Aayog



SEMICONDUCTORS are the true champions of the technology world, powering everything from toys to cellphones to vehicles, from behind the scenes. They have fostered breakthrough technologies in recent years, like artificial intelligence and machine learning completely changing the way we live and work.

Semiconductors have become the backbone and a prerequisite for any endeavour in emerging technologies. With the introduction of IoT (Internet of Things) and 5G technology in India, semiconductor chip consumption is expected to climb to about \$100 billion by 2025, up from \$24 billion currently. The current geopolitical situation places a premium on the security of essential information infrastructure, which is why reliable semiconductor and display sources are critical.

With the majority of semiconductor manufacturing and supply capacity concentrated in a few countries, including Taiwan, South Korea, Japan, US, and more recently China, governments around the world have realized that treating chip manufacturing as a strategic imperative is in their national interest. However, semiconductor shortages during the pandemic, as well as new geopolitical realities in semiconductor supply chains, intensify the need for reliable and trusted semiconductor sources.

Thus, the opportunity is huge and India also must capture this moment by creating an entire semiconductor and display ecosystem that can deliver innovative products.

India Semiconductor Mission (ISM)

The India Semiconductor Mission (ISM), which has been set up as a dedicated institution for the 'Semicon India Programme', is a new business unit inside the Digital India Corporation. ISM has been created with the goal of developing a long-term strategy for developing sustainable semiconductor and display manufacturing facilities, as well as a semiconductor design eco-system in the country. This mission aims to serve as a focal point for the comprehensive, coherent, efficient, and smooth deployment of the programme in consultation with government ministries, departments, industries, and academia.

Through the ISM, two silicon wafer fabs, two display fabs, as well as fabs for compound semiconductors, photonics, and sensors will be supported. Upstream activities such as



Image credit: ism.gov.in

Outsourced Semiconductor Assembly and Test (OSAT), Assembly, Testing, Marking, and Packaging (ATMP), and chip design will also be promoted through this mission. There are also attempts to catalyse business and academia to build an 85,000-strong talent pool of qualified semiconductor specialists at all skill levels, from technicians to researchers, which the industry requires.

With a Rs 76,000-crore incentive package through ISM, India has finally taken a giant step toward bringing semiconductor and display fab manufacturing to the country, at a time when supply shortages of the critical component have hit industrial production across the automotive, electronics, and other technology-led sectors. It is never too late for India to consider becoming a semiconductor manufacturing destination, given the country's long-term semiconductor demands and potential to establish a worldwide electronics manufacturing base. The required investment may be in the billions of dollars, yet the benefits significantly surpass the costs.

While India has earlier attempted to increase semiconductor production, this is the first time a scheme has been approved to increase semiconductor production, which is an essential component of modern technology products. Previous attempts to persuade firms to invest in India had failed miserably, but the government believes that the presence of a robust home market, as well as appropriate incentives and enablers, will succeed this time.

Towards Self Reliance

The objectives of ISM are also in line with the government's vision of an Atmanirbhar Bharat (Self-Reliant India). Semiconductor consumption in India is growing at a 15% annual rate and currently, India imports all of its requirements. With the fast acceptance of digital items such as smartphones, laptops, electronic gadgets, and IoT devices, as well as new-age cars and trucks, foreign exchange outflows have reached alarming levels.

India has been striving to attract chip manufacturers, but expensive capital requirements, lack of infrastructure, and prior knowledge have proven to be obstacles in the past, which will now be mitigated to a large extent by ISM. The plan to enhance semiconductor production will bring in significant investments and create huge employment, in addition to reducing the country's reliance on imports. The significance of ISM can also be seen in the fact that an investment of over Rs 1.70 lakh crore is expected to be made through ISM in the next four years.

Innovation Key to Success

Substantial R&D is widely recognised as a crucial component in supporting, pioneering, and leading many thrusts in the semiconductor ecosystem. Every country with a large semiconductor sector has made significant investments in semiconductor R&D centres, which act as a bridge between academia and industry.

From the early 1970s 10 μm technology to today's 7 nm devices, the industry has developed, with industry

leaders aiming to build incredibly small chips: 5 nm, 3 nm, and even smaller. ARM, Qualcomm, Intel, Cadence, and Texas Instruments are among the worldwide semiconductor corporations that have created design and software development infrastructure in India, assisting in the development of a critical mass of chip development expertise. That talent should be put to work supporting entrepreneurs with chip design and the creation of a fabless semiconductor ecosystem.

Government-funded academic institutions and local technical entrepreneurs should now lead the R&D effort in supporting indigenous manufacturing. India must increase investment in advanced semiconductor R&D, in addition, to aggressively investing in manufacturing and production capabilities, to fuel the next generation of innovation and leadership in this essential industry.

As chips become smaller and more competitive, semiconductor businesses will require a new strategy that takes into account everything from fab size to supply-chain challenges. Some of these challenges are:

- **High Investments:** Semiconductors and display production is a highly complex and technology-intensive industry that requires major and sustained inputs due to large capital investments, high risk, long gestation & payback periods, and rapid technological developments. Even on a small scale, a semiconductor fabrication facility can cost multiples of a billion dollars to set up, lagging behind the latest technology by a generation or two.
- **Lack of Fab Capacities:** India has a good chip design talent pool, but it has never developed chip manufacturing capabilities. ISRO and DRDO both have their own fab foundries; however, they are primarily for their own needs and are not as advanced as the most advanced in the world.
- **Lack of Skilled Workforce:** When it comes to India becoming a prominent player in semiconductor chip manufacturing, there is clearly a shortage of skill. Semiconductor manufacturing is a complex and research-intensive sector, defined by rapid changes in technology that require a significant set of skills.

Way Forward

There are some key areas and sectors that India needs to focus on for successful outcomes of the India Semiconductor Mission:

- Future chip production should not be a one-trick pony, but rather a multi-tiered ecosystem that includes design, fabrication, packaging, and testing. In this industry, India must also improve research and development to maximize self-sufficiency.
- Given the long gestation periods and rapid technological changes, India must out-strategize

on design and functionality, as the final product will be available only three to four years after work begins, by which time the current chip shortage will have been resolved and technology will have advanced even further.

- The raw materials utilised in the semiconductor manufacturing process, particularly gases and ultra-pure chemicals, require substantial R&D. As circuits get smaller, more novel materials are needed to make semiconductors. Thus, materials utilised to build microchips must be discovered, developed, and formulated.
- For cutting-edge R&D, there should be a collaboration with various R&D centres such as IMEC (Interuniversity Microelectronics Centre), GlobalFoundry, AMD (Advanced Micro Devices), VDEC (VLSI Design and Education Center), Intel, Qualcomm, Samsung, ST Microelectronics, etc.
- Establish government-funded centres for the production of electronic-grade silicon and monocrystalline wafers.
- To bridge the technology gap, there is a need to set up an R&D Foundry that would enable the development of Process Design Kits (PDK) for the next generation of devices (below 28 nm and up to 1 nm). This may be strengthened by collaborating with the major R&D Fabs.
- As part of the policy framework of ISM, it is essential that the products manufactured by Indian foundries be preferred over the imported ones. For ensuring profitability, the viability gap funding may be provided.

Realising the Dream

With significant fiscal incentives and non-fiscal benefits, India's semiconductor dream is likely to come true, contributing significantly to the country's goal of a \$1 trillion digital economy and \$5 trillion GDP by 2025, as well as having a multiplier effect on allied sectors like electronics, telecom, automotive, railways, and electrical products. Semiconductors are like building blocks of electronics or oil for the energy or automobile sector. It is imperative that we produce them locally to become Aatmanirbhar to some extent and also feel safer from the cyber or digital security perspective. Hence, having an indigenous semiconductor foundry or fab is the need of time.

The ISM will undoubtedly boost semiconductor and display manufacturing, which is a wise move that will benefit India, particularly at a time when the world is experiencing a semiconductor shortage. As the ISM enters its implementation phase, the government needs to be both supportive and vigilant to ensure that companies stick to their commitments and pledges to make India's semiconductor journey a success.



WASTE TO WEALTH MISSION



The Goal – Zero Landfills

Dr Shailja Vaidya Gupta
Adviser, Department of
Biotechnology
Ministry of Science &
Technology
Email: shailja.psa@gov.in

THE Hon'ble Prime Minister launched the Swachh Bharat Mission on 15 August 2014. The government is committed to take the Swachh Bharat Mission to the next level. 'The Swachh Bharat Mission has transformed one side of swacchata, now we will get latest technologies to transform Waste to Energy and Wealth in a major mission'.

The PM-STIAC (Prime Minister's Science, Technology and Innovation Advisory Council) recommended establishing a Waste to Wealth Mission (W2W) which would identify real time major waste problems and sentinel sites across India and deploy latest technologies addressing waste across India. Consequently, the Office of the Principal Scientific Adviser to the Government of India set up a Waste to Wealth mission to test, validate and provide technological solutions for the management of waste.

The 'Waste to Wealth' Mission aims to identify, test, and validate affordable decentralised technologies, adaptable to local requirements for waste management. Waste management in the developing world is critical for both climate change and global health; it is imperative that the very core of the climate change and global health is addressed. The solutions validated and demonstrated are exemplars which address waste management on site, in a decentralised manner, leading to decreased transport costs in waste handling, with a goal towards zero landfill.

Waste – The Challenge

In India, waste and waste management is a complex challenge with multiple components. The rough estimate of total waste generated every year is 1236 MT with no estimate of waste dumped into our water bodies. Some waste is unique to India such as pan masala, shampoo, etc. sachets, hair waste, animal/food/agri waste discarded without thought. And so, India has to find its own solution for managing this waste.

Waste management is a universal issue affecting every single person in the world. Currently, about 2.01 billion

metric tons of Municipal Solid Waste (MSW) is produced annually worldwide. The World Bank estimates overall waste generation will increase to 3.40 billion metric tons by 2050. An estimated 13.5% of today's waste is recycled and 5.5% is composted, between one-third and 40% of waste generated worldwide is not managed properly and instead dumped or openly burned.

Poorly managed waste is contaminating the world's oceans, clogging drains and causing flooding, transmitting diseases via breeding of vectors, increasing respiratory problems through airborne particles from burning of waste, harming animals that consume waste unknowingly, and affecting economic development such as through diminished tourism. Unmanaged and improperly managed waste from decades can create unimagined misery for generations to come. Therefore, investing in waste management is critical and a no-brainer.

The Global Waste Management market is expected to grow from \$285 billion in 2016 to \$435 billion by 2023, growing at a compound annual growth rate (CAGR) of 6.2 %. The Global Waste Recycling revenue will grow exponentially, especially for plastic and electronic waste. The World Bank already has a record of investing in waste management infrastructure across the globe. It has moved more than \$4.7



Burning, dumping or discharging a tonne of rubbish into waterways cost South Asian economies \$375 through pollution and disease, against \$50-100 required for basic systems to dispose of that same (one) tonne properly.

McKinsey, 2016

billion to more than 340 solid waste management programs since 2000.

The Waste Conundrum

Waste management is complex because of the multiple agencies and responsibilities:

1. Collection of waste*

- Municipal Solid Waste – Civic/household
- Waste from water bodies
- Waste from soil (MLP, sachets and other plastic waste contaminating our top soil, etc.)
- Animal/cattle waste

2. Treatment of waste*

- Legacy waste – about 80% waste in landfills like Ghazipur landfill is inert and cannot be used as Refuse Derived Fuel (RDF) and needs technology that can reuse the inert material constructively, such that it can be disposed-off.
- Pyrolyse waste which is beyond reuse/recycle (toxic)
- Waste to Energy (electricity, biofuels, etc.)
- Waste to Value (recovering valuable material from waste)

3. Advanced technology for use of waste

- Torrefaction of biomass waste to bio-coal, use of the inert material for road construction, etc.

(*For both collection and treatment of waste in the complex Indian conditions, decentralized, in-situ solutions need to be developed.)

To add to the above complexities is the large number of stakeholders involved in the waste chain in India:

- Local urban bodies
- Municipal Corporation; different collection bodies for MSW, the water bodies in India, open drains have both MSW, dead animals, etc., have different collection system.
- State government
- Various Ministries of the central government (Ministry of Environment, Forest and Climate Change, Ministry of Drinking Water and Sanitation, Ministry of New and Renewable Energy, Ministry of Chemicals and Fertilizers, Ministry of Agriculture & Farmers' Welfare, Ministry of Power, etc.)

Decades of neglect, lack of foresight and complete absence of urban planning has left India staring at mountains of waste-landfills, waste-choked drains, water bodies and rivers. The cumulative consequence of decades of neglect has created “legacy waste”.

“
Authorities in Morocco believe that \$300m they have invested in new sanitary landfills has already averted \$440m in environmental damage.”

Ref: “How the world should cope with its growing piles of rubbish”, *The Economist*, September 29, 2018 edition

There are about 48 recognised landfills across India, together covering nearly 5,000 acres of land, with a total land value of about Rs 100,000 crore. India generates about 275 million tonnes of waste per year. With current waste treatment rates of about 20-25%, this leaves majority of waste untreated, in a heap, on landfills, and an equal amount in drains and river bodies.

Drains and water bodies, emptying out into Indian rivers, also carry with them an unimaginable amount of waste. The Ganga is among the top 10 polluted rivers in the world, together accounting for 90% of the total ocean plastic pollution.

Municipalities need to have access to affordable technology which has been piloted and validated under Indian conditions. Today, most of the technology/equipment needed for waste management is imported, expensive and often not suited to our varied local situations.

India needs affordable, decentralised, customised solutions for its land-constrained complex city matrix. For example, amphibian equipment to clean water bodies is imported; indigenisation of design and manufacturing of such equipment for smaller drains and water bodies is essential. Robotic long-hand scavenging machines to unclog drains, booms that filter and prevent waste in our drains entering a larger water body are some examples, where Atmanirbhar Bharat (self-reliant India) needs to kick in immediately. Entry to drains in India is choked with pan masala, shampoo sachets, chips/kurkure packets and so on, causing instant flooding of cities and towns during the monsoons.

Waste to Wealth Mission: Decentralised Solution

Waste collection and recycling is now a financially viable business. Plastic and electronic waste is premium uptake by the unorganised sector. The Municipal Solid Waste (MSW) continues to be a challenge with need for minimum land requirement and technology emergent.

The Waste to Wealth Mission in collaboration with the East Delhi Municipal Corporation (EDMC) has established a Decentralised Waste Management Technology Park at New Jaffrabad, East Delhi. The Technology Park is a pilot, providing end-to-end solutions for waste management, from semi-automated segregation of municipal solid waste to on-site compaction and treatment of the waste.

Municipal solid waste will be segregated onsite into combustibles fractions and non-combustible (compostable)

Advantages of Technology Park

*Zero waste, Zero energy,
Zero landfill*

- Decentralized on-site waste processing
- Minimum land requirement
- Onsite waste treatment, processing, compaction, and possibility of conversion to energy
- Reducing secondary waste transportation cost
- Moving towards zero landfill
- Scaled up/replicated across various cities in India



Jafrabad Dhallao (Before)



Jafrabad Dhallao (Before)



Jafrabad Dhallao (Before)



Jafrabad Dhallao (After)

fractions. The combustible waste will then be processed on site, leaving less than 5% of inerts reaching landfill. In addition to incoming MSW, floating waste from adjacent 52-cusec drain will also be collected and processed on site.

This pilot will ensure Solid Waste Management Rules 2016 compliance of ULB's for reducing load on landfill sites, without procurement of new land for waste disposal. The area required for the pilot is 1100 sqmt of area (area currently utilized for open dumping or secondary collection site) with a waste processing of 10 tonnes per day.

Decentralised processing of waste is a step towards "Zero Landfill" with the added advantage of reduction in the transportation of the waste. The successful demonstration of this pilot will allow the model to be replicated in cities, towns and villages across India.

The Decentralized Waste Management Technology Park has piloted five technologies with integrated approach for one-stop solution for incoming fresh waste:

1. **'Xaper'** (by M/s E3 Waste Solutions, Punjab) - An indigenous semi-automated technology that segregates fresh mixed municipal solid waste into compostable, recyclable, combustible, and inert fractions. The local open dump site or dhalao is replaced by Xaper for onsite segregation and processing.
2. **'Plasma pyrolysis Unit'** (by IIT Delhi) - for thermal disintegration of carbonaceous material in an oxygen-starved environment into environment friendly components.
3. **'Enviro-RISE R-A1100'** (by M/s DESMI India LLP) - technology from Denmark for removal of floating solid waste from the 52-cusec drain flowing adjacent to the technology park site.

4. **'Gasifier'** (by M/s GD Environmental Pvt. Ltd., Maharashtra) - A 150 kg/h plant for gasification of municipal solid waste (including COVID-19 waste) and possible conversion to energy.

5. **Johkasou STP** (by M/s Daiki Axis India Pvt. Ltd., Delhi) - A decentralized sewage treatment technology to meet the operational and non-potable water requirement at the site through treatment, recycling and reuse of wastewater flowing in the 52-cusec drain.

Community Engagement: Integral to Waste Management

The Waste to Wealth Mission recognises that community or "Jan Bhagidari" engagement is the crux of successful waste management. Two very successful programmes have demonstrated the effectiveness of community engagement.

Swachhta Saarthi Fellowships: Initiated to empower citizens and individuals who are engaged in community work of waste management, waste awareness campaigns, waste surveys, etc. and provide them Swachhta Saarthi fellowship.

The fellowship was launched in 2021 to recognize students, community workers/self-help groups, and municipal/sanitary workers who are engaged in tackling the enormous challenge of waste management, scientifically and sustainably. The fellowship is aimed at amplifying the role of young students from schools and colleges, and citizens working in the community through Self Help Groups (SHGs), or in independent capacity in sensitizing the society towards waste management and offer innovative solutions for conversion of waste to value. The 2021 cohort had 344 Swachhta Saarthis consisting of high school students, college



- Door-to-door research of 200 households on willingness to participate in decentralized solutions
- Mapping of systems to assess waste streams, volumes and capacity to create local solutions for waste
- Identification of decentralized technologies to address organic waste
- Pilot installation of biogas units at three temples and 1HH Biogas Plant.

Behaviour Change Solutions. Decentralized waste-to-wealth Approaches: Temple Waste to Gulaal, Dhoop, Gulkand, organic waste to Compost & Biogas Selecting the right unit for Community-Composting at Temples. Composting technologies for waste recycling options based on space/cost/maintenance efficiency. Final units selected were based on no requirement for electricity to run, affordability, small space in which the unit can be fitted, modularity in case it needed to be moved.



students, and community workers from across 27 States and 6 UTs that are currently making an impact through their efforts in waste management towards building a sustainable future.

Su-Dhara Programme: Su-Dhara is a model for addressing urban waste by aligning science and technology with behavior change approaches. Communities can participate in enabling segregation and recycling to generate waste-to-wealth solutions. Vertiver, an NGO, oversees this programme. The methodology adopted was:

Awareness, Outreach & Training

Several measures have been adopted to spread awareness about the concept and its various programmes.

- Creation of community volunteer groups for addressing waste issues through “champions”.
- Extensive Community engagement through one-on-one interactions, communication materials, workshops, *nukkad nataks*, art competitions, murals, award ceremonies and ongoing feedback and reward systems for champions to generate buy-in and momentum for addressing waste at local levels
- Creation of SHGs to promote entrepreneurial models for products created from waste.

Efforts are also being made as part of the mission to train & build capacity among the various stakeholders to carry the movement forward. These include:

- Engaging with Ward Councillors and EDMC to help scale up activities in other wards
- Training waste workers and communities on working together at Gali, Temple, Ward level to co-create solutions
- Training communities in making compost, gulal and managing biogas unit
- Training women to set up their own SHGs to sell products made from waste.

In addition, urgent attention is also needed in the development of skilled and trained professional personnel to operate and maintain the waste management chain, right from collection, operation and maintenance of waste-handling plants. Central, and integral to success, is design in the collection of centralised and decentralised waste treatment plants, and of the equipment used. Design of waste management should be the bedrock of a well-planned smart city, town or village.

National Mission on Biodiversity and Human Well-being



Dr Ketaki Bapat
Scientist F
Office of the Principal
Scientific Adviser
Email: ketaki.bapat@nic.in

THE diversity of India does not restrict itself to culture, languages, and traditions but also extends to the varied flora and fauna. India, one of the 17 mega-biodiverse countries in the world, accounts for 7-8 percent of the world's recorded species and four of the 34 global biodiversity hotspots. The National Biodiversity Authority (NBA), a Statutory Body set up by the Ministry of Environment, Forests and Climate Change (MoEF&CC) facilitates conservation, sustainability of biodiversity and use of biological resources.

Globally, there has been a 7% loss of intact forests since 2000, and recent assessments indicate that over a million species might be lost forever during the next several decades. Further, climate change and the ongoing pandemic will put additional stresses on our natural ecosystems. A World Bank report (Mani, 2015) estimates that the gradual diminishment of India's rich natural asset-base and the reduction in flow of ecosystem services may be resulting in annual losses of at least 5.7% of Gross Domestic Product (GDP).

Why National Mission?

Today, it is becoming clear that repairing our dysfunctional relationship with nature is one of the ways to mitigate climate change and curtail future outbreaks of infectious diseases, and ensure food security leading to overall well being of the people and planet. The efforts at various stakeholder levels are still fragmented and need to be synergised. Mission level efforts at the national level would help to address biodiversity holistically.

The concept of the National Mission on Biodiversity and Human Well-Being was presented by Dr Kamal Bawa, a well known environmentalist, to the Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) – an overarching Council, chaired by the Principal Scientific Adviser (PSA) to the Government of India. The Council has recommended the ambitious government mission that strives to bring to the limelight the issues of conservation and biodiversity.

The National Mission on Biodiversity and Human Well-Being is being led by MoEF&CC and coordinated by the Office of the Principal Scientific Adviser to the GoI (PSA

Office). The Mission lays down a framework for biodiversity conservation integrating biodiversity, ecosystem services, climate change, agriculture, health, bio-economy and capacity building in the realm of biodiversity science.

The Mission aims to link biodiversity with the economic prosperity of people and thereby transform biodiversity science in India. It envisages using the country's rich biodiversity to find solutions to challenges in climate change, health and agriculture domains calling on Governments, NGOs, and other institutions to work together to catalogue, evaluate, map, monitor biodiversity in a sustainable manner.

Mitigation programmes will lessen the impacts of climate change and other natural disasters such as pandemics and floods. We can rejuvenate agricultural production systems and increase rural incomes from biodiversity-based agriculture while also creating millions of green jobs in restoration and nature tourism. Restoration activities across India's degraded lands, which amount to almost a third of our land area, alone could generate several million jobs.

The mission has well conceptualised and formulated a dynamic biodiversity-based sustainable economy anchored by a reliable information system. The pandemic has exposed the dysfunctional relationship between humanity and nature and the proposed mission would help in boosting rural economy with community connect, enabling cultural change, and promoting nature-based solutions.

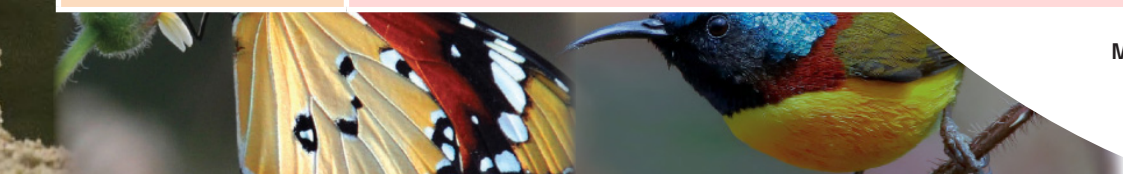
The planned Mission recognises that we need a strong cadre of human resources to meet the enormous and complex environmental challenges ahead and gains of environmental change will be upheld and carried forward by cultural change through learned professionals. The salient outcomes of the proposed Mission include, a comprehensive documentation of India's biodiversity including cultural and traditional practices, assessment of conservation status, development of human resource adept at handling of environmental data for monitoring, and enhanced agricultural production and livelihood security.

Let's hope the Mission gets rolling soon.



The proposed National Mission comprises seven verticals

Vertical	Objectives of the Mission
1. Nisarga Bharat	Exploration, Discovery & Genetic Characterisation of India's Biodiversity - Undertake field explorations of unexplored geographical areas and understudied species-rich groups. - Working with BSI, ZSI and other institutions, enhance India's capacity to incorporate latest concepts and tools to document, explore and discover India's biodiversity. - Deploy and develop molecular tools such as DNA sequences. National Framework for electronic People's Biodiversity Registers (e-PBRs) - Develop cloud embraced distributed national infrastructure for electronic People's Biodiversity Registers and "Indian Catalogue of Life (ICoL)", a curated, validated, accurate, and authenticated backbone of scientific names, their scientific variants and common names in different regions & languages through national surveys such as by BSI, ZSI, and bureau of microorganisms, virus and fungi and other reputed national, regional research and academic institutions. Cataloguing and Mapping Life of India (CML) - Cataloguing and mapping biodiversity to build an open access, validated and national spatio-temporal repository of the biodiversity of India using next-generation sequencing technologies. Diversification of livelihood opportunities and enhancing incomes of rural households through biodiversity-based skill development.
2. Biodiversity & Ecosystem Services	Map the spatial distribution of ecosystem services and determine underlying drivers of ecosystem service provisioning, managing and conserving species and ecosystem services.
3. Biodiversity, Climate Change & Disaster Risk Management	- Quantify and map the key risks to biodiversity and ecosystem services from climate change, with special emphasis on mountain ranges like the Himalayas and the Western Ghats and river ecosystems. - Assess and map the role of biodiversity and ecosystem functions in disaster risk mitigation, including plans for synergising India's emerging low carbon economy and Intended Nationally Determined Contributions with the conservation of biodiversity and ecosystem services.
4. Biodiversity & Agriculture diversity	- Conservation and diversification of agro-biodiversity - Development of methodologies to quantify the contribution of biodiversity to primary and secondary agriculture. - Assess agricultural productivity in enhancing food and nutritional security.
5. Biodiversity & Health	Medicinal Plants and Health Security - Promote in situ conservation of medicinal plants. - Build capacity in multiple institutions in five States. - Document traditional knowledge by employing services of folk healer associations and Traditional Knowledge (TK) organisations. OneHealth and Zoonoses - Create National and regional prioritisation of zoonotic pathogens, through assessment of public health threats. - Determine Emerging and Re-emerging Infectious Diseases (ERID) hotspots by mapping potential emerging and re-emerging infectious diseases (ERID) of zoonotic origin. - Identify and foster capacity for Integrated OneHealth Surveillance of key taxonomic groups across potential ERID hotspots. - Network partner institutions and experts for building regional rapid response capacity. - Setup Sentinel Surveillance sites across India based on ERID hotspots and regional rapid response capacity.
6. Biodiversity & Bio-economy	- Capture bio-resource-based economic activities generating livelihood data (over time) - Construct area-specific bio-economic models - Estimate market value of a sustainable flow of selected bio-resources.
7. Biodiversity, Capacity Building & Outreach	- Community and citizen connect; strengthen student community in biodiversity-related fields through various programmes. - Improve science communication and public discourse on India's biodiversity. - Create a digital platform to act as a repository for curated content.



Electric Vehicles Mission

Leap Towards a Greener Future



Dr Sneha Malhotra

Office of the Principal Scientific Adviser to the Government of India
Email: sneha.malhotra@nic.in

Dr Preeti Banzal

Adviser/Scientist G
Office of the Principal Scientific Adviser to the Government of India
Email: preeti.banzal@nic.in

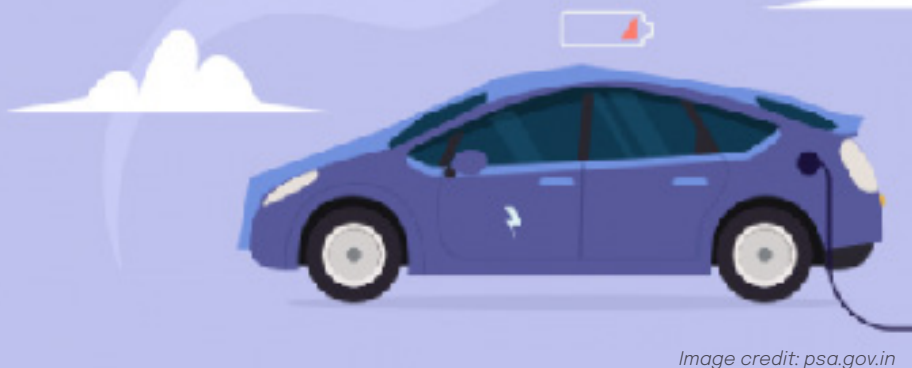


Image credit: psa.gov.in

It needs 360° integration across government, businesses and consumers to achieve a robust and rapidly growing EV ecosystem which will enable India to leapfrog to be a global leader in the manufacturing of EVs and ensure sustainable, environment-friendly mobility. It can further improve India's overall energy security situation wherein we currently import \$100 billion (blog. mygov.in/editorial/indias-electric-vehicle-push-will-lead-to-brighter-greener-future/) worth of crude oil which forms over 80% of our crude requirements.

INDIA'S automotive industry currently contributes 7–8% of its annual GDP (www.investindia.gov.in/sector/automobile) and is primarily dominated by fossil fuel-based vehicles. However, there is an accelerating shift towards electric mobility, driven by the need for improved air quality, reduced dependence on oil imports, positive climate action, and decarbonisation of end-use sectors (World Economic Forum and Ola Mobility Institute 2019) nationally and globally.

As one of the leading five car markets globally, India is expected to have approximately 400 million user-based mobility solutions requirements by 2030 (blog.mygov.in/editorial/indias-electric-vehicle-push-will-lead-to-brighter-greener-future/). To satisfy this requirement, and also to meet out CoP26 commitments, there is an impending need for a paradigm shift across all the mobility domain stakeholders – from the government to the industry to the end-users.

India is one of the few countries that have supported the global EV30@30 campaign which aims to have electric vehicles forming at least 30% of new vehicle sales by 2030. Therefore, avoluminous transition towards Electric Vehicles (EV) is already on the horizon.

Need for Electric Mobility

India has added over 20 million vehicles every year on average for the past ten years. It is not feasible to sustain this constantly rising number of vehicles running on imported high-cost fuel while adding to the infrastructure bottlenecks and severe air pollution. According to the *World Air Quality Report, 2020* by IQAir, a Swiss organisation, India is home to 22 of the world's 30 most polluted cities (www.iqair.com/in-en/world-most-polluted-cities).

In India, the transport sector is the third most carbon dioxide emitting sector, and within the transport sector, road transport contributed more than 90% of total carbon dioxide emissions (*Emissions inventory for road transport in India in 2020: Framework and post facto policy impact assessment*). Globally it is responsible for 25% of total carbon dioxide emissions from fuel combustion while being a significant contributor to global greenhouse gas emissions.

A recent International Council on Clean Transportation (ICCT) analysis stated that the shift from internal combustion-based (ICE) to Battery Electric Vehicles (BEVs) would reduce total lifecycle carbon dioxide equivalent emissions by around 65% based on the current average energy mix in

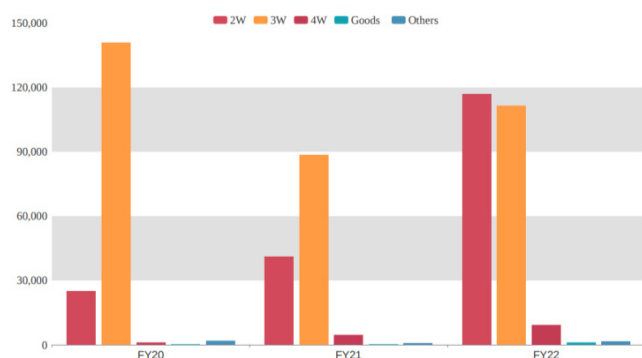
Europe and by 83% with entirely green electricity (<https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/why-the-automotive-future-is-electric>).

Currently, Hybrid electric vehicles, plug-in hybrid electric vehicles and Battery Electric Vehicles (BEVs) are commercially available in the market. Apart from these, several other electric vehicle formats with energy being obtained from hydrogen-based fuel cells, solar cells, and others are in the experimental domain.

Electric Vehicle Scenario in India

The present EV market in India is just about 9.16 lakh electric vehicles (0.33%) of the total stock of vehicles in the country. The majority of sales are driven by the two- and three-wheeler segments while electric cars are yet to get a measurable foothold. In the period April-December 2021, about 9052 electric cars have been sold. It is a significant jump from the 900 cars sold in FY20 (Vahan Dashboard, Ministry of Road Transport and Highways), but it is still a long way. The total stock of electric vehicles in India as of December 2021 is 9.16 lakh.

Electric Vehicle Growth in India



The first electric car in India was the Reva by Mahindra launched in 2001, which sold a few units in the initial years. In 2010, the Prius hybrid was launched by Toyota followed by the Camry hybrid in 2013. In recent years, several manufacturers including Tata Motors, Hyundai, KIA Corporation, Bajaj Electric, and Hero Electric have introduced several electric variants of two, three and four-wheelers.

The Government of India has taken multiple initiatives to develop and promote the Electric Vehicle (EV) ecosystem, from the Faster Adoption and Manufacturing of Electric Vehicles (FAME) schemes on the consumer side to the Production Linked Incentive (PLI) scheme for auto and automotive components on the manufacturing side to PLI for Advanced Chemistry Cell (ACC) on the supplier side. Further, there have been G2G dialogues and MoUs between India and mineral-rich countries such as Argentina, Brazil, Chile and Australia to establish a secure supply of critical minerals – such as lithium and cobalt – required for the electric vehicle supply chain.

There is an equal push from the Indian entrepreneurial ecosystem which is churning out startups with innovative, tech-driven offerings that are enabling the development of a robust EV infrastructure while contributing towards a sustainable future.

- ✓ DST-PSAO Group on EV Infrastructure Interim Report on Indian Standards published in June 2021.
- ✓ Report on Consultative Group on Future Transportation published on 30 September 2021 under the chairmanship of Dr V. Sumantran.
- ✓ Department of Heavy Industry prepared the comprehensive document on 'National Electric Mobility Mission Plan 2020'.
- ✓ Under the initiative of this group, the Bureau of Indian Standards (BIS) has notified in August 2021 the Light Electric Vehicle AC Charge-point standards which form the world's first formal standard on AC charge points for two and three-wheelers.

Electric Vehicles Mission

The Prime Minister's Science, Technology Innovation and Advisory Council (PM-STIAC) was constituted on 28 August 2018 under the Chairmanship of Prof. K. VijayRaghavan, Principal Scientific Adviser (PSA) to the Govt of India, to appraise the status in specific science and technology domains, comprehend challenges, formulate interventions, develop a futuristic roadmap and advise the Prime Minister in these matters. The PM-STIAC envisioned nine science-technology missions, which among others, include a mission on Electric Vehicles (EV-Mission).

The EV-Mission is critical for India to reduce fossil fuel consumption and mitigate emissions by facilitating the production of Electric Vehicles (EVs) economically. It aims to develop vehicle sub-systems and components specific to Indian requirements and to assist the speedy adoption of electric vehicles by making their use viable.

The objectives of the Mission are to facilitate focused research & development and innovation to build indigenous capability and to develop vehicle subsystems and components for Indian requirements including rare-earth-based electric motors, Li-ion batteries, power electronics, etc.

Under this Mission, the Office of the PSA constituted a Consultative Group on Future Technology (CGFT) in 2018, with a mandate to advise the government on matters related to emerging transportation technology. The CGFT had participation from automakers, suppliers from the auto industry and electronics industry, members of the committee of the Bureau of Indian Standards (BIS), and homologation and certification agencies including the Automotive Research Association of India (ARAI). The Group was requested to address the following topics to accelerate migration to electric mobility:

- Carbon dioxide reduction opportunities,
- Addressing poor air quality arising from tail-pipe emissions from conventional vehicles, and
- Reduction of oil imports.

The committee, after multiple consultations, observed that while there has been an encouraging level of activity among many start-ups and established manufacturers to roll out new Electric Vehicles (EVs), the adoption of EVs

would likely be paced by the availability of EV charging infrastructure. To further examine this issue, in June 2020, the Office of PSA jointly with the Department of Science and Technology (DST) constituted a DST-PSAO Group to guide the development of Indian Standards for EV Charging Infrastructure under the Chairmanship of Dr V. Sumantran, a lead-member of the CGFT. DST has also been involved in developing appropriate standards in the country for products, including Electric Vehicle Supply Equipment (EVSE). The Group was requested to address the following issues:

- a. Low-power AC charging points at an affordable cost for 2 or 3 wheelers
- b. Normal power parking bay charging infrastructure (both AC and DC)
- c. High-power charging infrastructure for buses.

Low-power AC charging points at affordable cost for 2 or 3 wheelers

While most industrialised nations have focused on charging systems for cars (each usually costing in excess of several lakhs of Rupees), for India the initial scale will emerge from 2-Wheelers and 3-Wheelers. A large fraction of the charging systems needed in India will have to be sized suitably and be produced at high affordable cost to be viable and achieve the required scale of deployment across the country. Guided by this, the group set about developing an innovative new solution with the help of a sub-committee drawn from industry, government agencies, and academia. The Group identified a breakthrough in affordability and standards were developed with close involvement of a broad cross-section of OEMs, component suppliers, Discoms, cellular operators and ARAI.

- The draft standards were developed after manufacturing a limited number of representative prototypes (from multiple suppliers) and testing and validating them. The system was also configured to allow powerful data analytics at the back-end to monitor and improve performance.
- A basic smartphone app that would operationalise the system and allow extensions to back-end analytics was also a part of the testing and pilot.
- A design competition was carried out for the students of the National Institute of Design (NID), Ahmedabad, in June 2020, resulting in aesthetically appealing and ergonomically novel designs.
- Based on the proposed product, draft specifications and standards for a low-cost AC charging point for 2-wheelers/3-wheelers were finalised. The objective is the widespread proliferation of low-cost AC charging points, in urban areas to start with.

NITI-Aayog, the Ministry of Consumer Affairs and the Bureau of Indian Standards (BIS) supported this initiative for adequate testing and validation. A pilot project on ‘Prototyping & Field Validation of Light Electric Vehicle AC Charge Point’ was initiated through the Automotive Research Association of India (ARAI), Pune, with fund support from DST. This project includes integration and validation of the user-friendly mobile App that would handle the functions of charge points location finder, user e-authentication and e-wallet billing. The Charge Point Device is expected to cost under Rs. 4,000/-per charge point. Hundred prototype devices were deployed by August 2021 in the cities of Delhi and

Bengaluru and are being validated by several manufacturers and institutional users.

Normal power parking bay charging infrastructure (both AC and DC)

Activities related to this domain have been facilitated by the Group and Sectional committees formed in the BIS. The current work is being led and undertaken by the BIS Sectional Committee ETD-51.

High-power charging infrastructure for buses

Keeping in mind that the industry and fleet operators will need to deploy different kinds of systems based on route demands, duty cycle, and space for infrastructure, the Group addressed the three mainly relevant alternate solutions for high power charging of e-Buses. These systems are similar to those also employed in most global markets: High Power Automated Connector Charging (also called ACD/Opportunistic Charging/Pantograph charging); High Power Plug-in DC Charging, and Swapping of Batteries in eBuses.

Unlike many previous efforts in this domain across the globe, efforts were made to ensure that interoperability is incorporated to increase volume-driven efficiencies for the country as these systems get deployed across the nation. The engineering specifications and protocols are derived from contemporary designs that are already successfully working across the globe. These standards will also be relevant for future e-Truck charging as well.

Globally, single-gun plug-in charging systems are widely deployed. Most systems allow operation up to 250 kW, although operational systems in India allow up to 150 kW limited by higher ambient temperatures and equipment specifications. Delivering a higher quantum of power requires more complicated systems that are capable of both higher capacity of thermal management as well as more sophisticated electrical contact management.

Since buses typically will have larger batteries (up to 300kWh) and therefore require faster-charging rates, many bus systems choose to deploy “dual-gun” chargers where two guns, each capable of up to 150 kW, may be used simultaneously. This allows the delivery of up to 300 kW of power and hence a shorter charging duration when the bus is not available for line operation. Managing the electrical and communication protocols for a dual-gun system requires more care and functionality from the charging system. The Group has addressed this challenge with what is likely the world’s first interoperable Dual Gun draft specifications.

The third approach employed globally to charge buses is to have a system where the battery can be swapped. This requires a unique design on the onboard system where the secure positioning of the battery is ensured and the design allows easy removal and fitment and provides safe and durable methods to connect (and disconnect) the system electrically.

At the same time, ground infrastructure also requires special care to handle and manoeuvre the heavy batteries for insertion and removal, as well as charging them off-line in a safe and efficient manner. The requirement for interoperability poses additional challenges in resolving the trade-offs. For both technical reasons and economic reasons, the motivation to converge to a single design for vital elements like battery

dimensions, connector specifications, etc. remains low. Unlike in the other standards, thus far, industry participants are unable to find a common ground on technical parameters and concur on the key specifications. Forcing the industry to conform to a specific interoperable standard prematurely may be unwise.

The Group, after detailed discussions involving technical, supply chain, operations and commercial review, sees merit in undertaking a more elaborate approach where the technical solutions are more thoroughly tested and the field and operations aspects are more fully comprehended.

National Mission on Transformative Mobility and Battery Storage

The Mission was launched in 2019 as the framework for a Phased Manufacturing Program (PMP), aimed at localising the production of Electric Vehicles (EV) and their components within the country. PMP is valid for 5 years till 2024 to support the setting up of a few large-scale, export-competitive integrated batteries and cell-manufacturing Giga plants in India.

The National Mission on Transformative Mobility and Battery Storage will determine the contours of PMP, and will finalise the details of such a programme. This multi-disciplinary Mission with an Inter-Ministerial Steering Committee is chaired by CEO NITI Aayog. The Steering Committee is comprised of Secretaries from the Ministry of Road Transport and Highways, Ministry of Power, Ministry of New and Renewable Energy, Department of Science and Technology, Department of Heavy Industry, Department for Promotion of Industry and Internal Trade, and Director-General, Bureau of Industrial Standards.

The broader objectives of the Mission are:

- Strengthening electric vehicle ecosystem
- Improving air quality
- Empowering domestic manufacturing ecosystem
- Ease of living
- Employment generation

Schemes for Electric Vehicles in India

The National Electric Mobility Mission Plan (NEMMP) 2020 aims to enhance national energy security, mitigate the harmful effect of fossil fuel-powered vehicles on the environment and develop domestic manufacturing capabilities. The NEMMP 2020 is expected to help with the sale of 6–7 million units of electric vehicles, and saving of 2.2–2.5 million tonnes of fossil fuel.

In 2015, the Department of Heavy Industry also formulated a scheme called Faster Adoption and

Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) scheme to promote the manufacturing of electric and hybrid vehicle technology and to ensure its sustainable growth. The first phase of the FAME scheme was implemented through four focus areas, namely: (i) Demand Creation, (ii) Technology Platform, (iii) Pilot Project and (iv) Charging Infrastructure.

Market creation through demand incentives was aimed at incentivising all vehicle segments i.e. 2-Wheelers, 3-Wheeler Auto, Passenger 4-Wheeler vehicles, Light Commercial Vehicles and Buses. In this phase, about 2.78 lakh EVs were supported apart from sanctioning of 465 buses to various cities/states with a total fund utilisation of -529 crores. Based on the experience gained during FAME-I, Phase-II of the Scheme (FAME-II) was notified with an outlay of -10,000 Crore for three years commencing from 1 April 2019.

The Government of India has also set a target of installing 175 GW of renewable energy capacity by the year 2022, which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro-power (www.niti.gov.in/sites/default/files/energy/175-GW-Renewable-Energy.pdf). This has the potential to improve the reliable availability of renewable energy and will be helpful for charging stations of EVs.

Further, the Production Linked Incentive (PLI) Scheme has an outlay of -18,100 crores for Advance Chemistry Cell (ACC) batteries and an outlay of -26,058 crores for Auto and Auto Components sector. Together, these PLI schemes will incentivise prominent domestic and international players to establish competitive manufacturing units for automobiles, auto components and advanced batteries in the country.

The Promise of Electric Mobility

The mobility problems will intensify as population and GDP growth drive increased vehicle ownership and miles travelled. Electric Vehicles are capable of improving the fuel economy but with existing technologies, the cost competitiveness is low when compared to traditional vehicles. The decreased consumption of fossil fuels and increased productivity may be achieved through advancements in technology about renewable sources of energy. The up-gradation of EV related technology may offer benefits to buyers, society, automobile manufacturers and policymakers.

The government has championed various initiatives and has provided subsidies of varying nature to boost the sector. The novel concept of Vehicle-to-Grid is an essential aspect of energy security and renewable energy and provides a decent mechanism to deal with global warming issues.

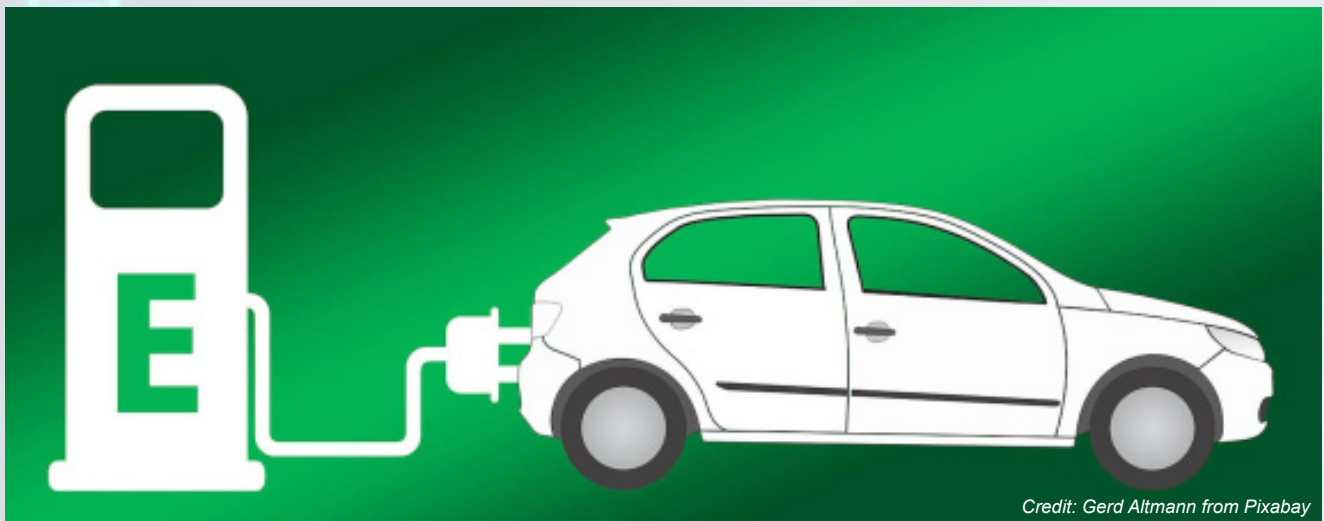
The push in the EV sector is also expected to play an essential role in generating substantial employment in the manufacturing of electric vehicles and their upstream components. The transformation of the sector towards sustainable mobility rests on rapid technological advances that allow newer electricity generating options, higher battery capacities, rapid battery charging and increased battery life. Going forward, technological shifts and changes in regulations will undoubtedly result in changing consumer behaviour towards electric vehicles.



Electrical Mobility: Gliding into the acceleration phase

From frugal to futuristic, *desi* innovation touches all Electric Vehicle areas. India is poised to be a world leader in the global switch to electric vehicles in 2022.

Anand Parthasarathy



THE typical lifecycle of a product or a process looks like an inverted 'V' with a long tail. It starts slowly as development meets demand, then shoots up to a tipping point when innovation sparks an explosion of usage, which finally tapers off, when a better, cheaper alternative is offered. Exceptional is the case, when technology becomes near-extinct, then experiences a rebirth, over a century later, creating a life-cycle graph that defies easy description. Into this rarest of rare category falls the electric vehicle.

An electric car, fuelled by batteries, was seen running in France for the first time on 19 April 1881 – and it continued to be the transport for the rich and famous, for another 30 years. Then came the first motor car running on petrol. It offered improved range, at an affordable cost – and sent the electric car to extinction – almost.

It was to take a full century for electric cars to become a good value proposition once more. Finally, it looks like its Second Coming is here and now. (see box: “Electric EVolution”).

What no industry pundit predicted was one recent development: the emergence of India as the focal point

in this global lurch towards electric transportation and, as potentially, the largest market for Electric Vehicles (EVs) in the world and a crucible for EV innovation. Market analysts all agree on the pace and potential of EV usage growth in India. Consider these recent findings:

- The electric vehicle market in India is poised to emerge as the leading market in the world and might be worth over \$ 200 billion by 2030, increasing annually at 30%-36%, says the India Energy Storage Alliance.
- The year 2022 could be a watershed year for EV adoption in India, driven by the commercial vehicle segment of 3-wheelers and small 4-wheelers, according to studies by the World Economic Forum. India is one of the supporters of the global EV30@30 campaign which aims to shift at least 30% of vehicle sales to EVs by 2030.
- The Dublin, Ireland-based Research and Markets.com estimate that the Indian EV market size will grow at a phenomenal 94.4% to reach the US \$ 152.21 billion by 2030.

- A recent report by logistics space company Indospace and investment specialist Colliers, says the EV segment in India is likely to attract investments to the tune of US \$ 12.6 billion over the next 5 years.
- Tamil Nadu is emerging as the EV capital of India, attracting over 1/3rd of all investments – and vehicle players like Ola Electric, Ather, Hyundai, TVS as well as battery manufacturers like Lucas TVS and LiEnergy, are coming to EV parks in Hosur and Manallur. Andhra Pradesh and Haryana are the other states with maximum EV manufacturing.
- Analyst Deloitte's Global Automotive Consumer study for 2022 says: "The Indian automotive industry is going to witness a new era of growth", with one in three consumers evaluating electrified vehicles.

With all this activity, estimates the Society of Manufacturers of Electric Vehicles (SMEV), Indians are ready to buy 1 million EVs a year, mostly two-wheelers. The Government is doing its bit with its FAME initiative — Faster Adoption and Manufacturing of Electric vehicles — with a Rs 10,000 crore corpus, now extended in its Phase II, till 2024. This provides incentives to manufacturers which help to bring down the selling price of two-wheelers by Rs 7000–20,000 and helps public utilities replace diesel public transport with electric buses, even while subsidising the cost of public charging stations.

In this upbeat environment, traditional vehicle manufacturers like Bajaj, TVS, Hero, Tata Motors and Mahindra, have been joined in their EV ventures, by a clutch of global brands as well as companies led by a new generation of young entrepreneurs with no legacy baggage to discard. Hence e-two wheelers with new names like Ola, Ather, Okinawa, PureEV and Ampere. And hence passenger e-car announcements from international players like Audi, MG, Skoda, Volkswagen, Volvo and Mercedes-Benz... all promising to hit Indian showrooms in 2022. Top-selling



Vehicle Assembly Line at Ather Energy Factory

3-wheeler rickshaws and goods vans include Mahindra, Piaggio, AtulAuto, Kinetic, Deltic Star and an interesting SN Solar Energy rickshaw that taps the sun for standby power.

Ather Energy unveiled what was the most high-tech smart scooter two years ago, offering GPS navigation, a large map screen, vehicle health monitoring and other smart features which are slowly trickling into the e-scooter mainstream. In spite of its premium

pricing upwards of Rs 1.5 lakhs, Ather has expanded into two manufacturing plants and has a capacity to roll out 40,000 scooters a year.

Ola Electric graduated from app-based taxi services to making electric scooters at its Hosur plant on the Tamil Nadu-Karnataka border. It claims a capacity of 10 million 2-wheelers a year at its robotic facility, making it potentially the largest automotive plant in the world as well as the only one with an all-woman workforce.



The Ola e-scooter factory is an all-women operation

Serving 'Last Mile' Logistics

The last two years of the Covid pandemic and its frequent lockdowns had one unforeseen side effect that was ironically to fast-track the EV revolution. With millions of Indians confined to their homes for long stretches, a small revolution took place that is variously called Quick Commerce or Last Mile logistics. Dozens of enterprising private players answered the pressing needs of households and served as a vital umbilical between the neighbourhood *kirana* shop or grocery, fast food eatery, vegetable vendor or pharmacist. An army of so called 'Gig' workers – young men and women driving 2-wheelers and 3-wheelers – do these essential door-step deliveries even today for a very small additional charge and the logistics of organising this last-mile ecosystem has attracted hundreds of tech-driven start-ups. The Hyderabad-based Smartron has designed the Flex e-bike, specifically for light cargo.



Hyperlocal delivery on a Flex cargo e-bike from Smartron, Hyderabad

In this highly competitive business, economics is key: almost all these operators realised that the electric vehicle was the best solution for such hyper-local transportation. Whether it is Swiggy or Zomato delivering food or Big

Electric EVolution

How EVs came, went and came again – after a century

Arguably the first human-carrying electric vehicle running on its own power was developed by the French inventor Gustave Trouvé who tested his vehicle on the roads of Paris in 1881, using a German electric motor from Siemens and a recently available rechargeable battery. Just a year or two later, an Englishman, Thomas Parker, who helped to develop electric trams in Birmingham, drove his first electric car in nearby Wolverhampton.

Technology-friendly Germany was home to many versions of the 'elektrowagen' in the 1890s. But a competitor was slowly creeping on the electric car – with the invention in Europe, the UK and the USA of the Internal Combustion or IC engine. This used explosive combustion of fuel (petrol and later, diesel), to push a piston within a cylinder and turn a crankshaft connected to the car's wheels.



The world's first electric car from Gustave Trouvé
(Photo credit: Jacques Cattelin – Wikipedia)

the name Bijlee to make its own e-wheeler in 1999 and a year later, the public sector BHEL developed an 18-seater e-bus. Bajaj Auto from Pune launched a 3-seater e-rickshaw. However, without a mature battery and recharging infrastructure and with zero government support, all these good ideas withered away.



The made-in-India G-Wiz electric car from Reva in London
(Photo credit: Frankh (Flickr) Wikipedia) and Reva founder Avtar Maini

In 1886, the German inventor, Gottlieb Daimler prototyped the modern petrol engine in 1885 and a year later Karl Benz patented the first petrol-driven 'motorwagen'. In France Rudolf Diesel invented the diesel engine in 1895. The American entrepreneur Henry Ford used this technology to mass-produce the first popular automobile – the Model T Ford – in 1908. It continued to sell till 1927 and at an average price of just \$260 it captured the mass market for cars. The electric car with its smaller range and the hassle of frequent battery charging fell by the wayside – and for almost a century was relegated to specialist applications like golf carts, forklifts or buses running inside airports.

In this limited mobility market, a few pioneering Indian players ventured into commercial EVs. In 1996, Scooters India, Lucknow, known to many of us as the maker of the Vijai scooter, developed the country's first electric 3-wheeler, Vikram. Mahindra started a firm in Coimbatore under

the name Bijlee to make its own e-wheeler in 1999 and a year later, the public sector BHEL developed an 18-seater e-bus. Bajaj Auto from Pune launched a 3-seater e-rickshaw. However, without a mature battery and recharging infrastructure and with zero government support, all these good ideas withered away.

In 2001, Avtar Maini, a post-graduate in electric storage technology from Stanford University (US), with 40 patents in battery technology to his name, decided to test the waters with India's first electric passenger car, REVA (short for Revolutionary Electric Vehicle Alternative). It was a tight fit for four passengers, but a thrilling (and silent ride) for the few hundreds who bought a Reva in India. With no government vision even in 2010, Reva received no official support and the asking price, which was more than that of a small petrol car, was not seen to be *paisa vasool* by canny Indians.

But other nations recognised the revolution that it represented... Reva was sold in some 24 countries. In the UK, it was branded G-Wiz and the City of London exempted it from the very heavy Congestion Charge and parking fees which could put an extra £ 600 into the owner's pocket every month by way of savings. The Reva, though a seeming failure in the land of its birth, was an idea ahead of its time. The name lived on after Mahindra took control of the company in 2010, with Maini staying on to smooth the transition. Today he heads two family businesses, Virya Mobility and Sun Mobility, still innovating in India's EV ecosystem.

On the global *maidan*, the revival of interest in electric mobility was similarly muted. It had to await the vision of Elon Musk in the US, who took over Tesla Motors in 2004 and five years later launched the Roadster e-sports car, followed by the Model S electric sedan. By assuring a range of over 300 km on a full charge, Tesla took on the entrenched petrol car market at its main selling point: range.

But the electric car still needed a tipping point, to push it, as a viable alternative to fuel-based cars. That point was reached with ever-rising global fuel prices.

For Indians, that came when the price of a litre of petrol crossed Rs 100 in mid-2021, an emotional and unsustainable *lakshman rekha* for many. Suddenly an electric personal vehicle began to look like a very good value proposition indeed.

Basket ferrying groceries or Dunzo or Porter delivering everything else... the common factor is the agent on an electric two-wheeler or for bigger operators like Amazon or Flipkart, a 3 or 4-wheeled vehicle.

If you don't own a two-wheeler, but still want to earn a living as a Gig worker, no problem! There are shared e-bike services like Bounce and Yulu, where you can pick up a bike in one spot and leave it in another. The Bounce Share e-scooter service in Bengaluru, which started in 2018, crossed 30 million rides and 170 million km on its dock-less scooter-sharing platform in January 2022. It is also the first to set up its own network of swapping stations, where drained batteries can be exchanged with charged ones, instead of spending time on recharges: it achieved 1 lakh swaps by February this year.

Yulu claims to be the largest e-mobility provider in India, with nearly 20,000 e-scooters and operations in Delhi, Mumbai, Pune, Gurugram and Bhubaneswar and Bengaluru. Its Yulu DEX e-scooter gives 60 km on a full charge and speeds up to 25 kmph. No driving licence is required for this class of scooter. Shadowfax Technologies, a leading



The battery of the Bounce e-scooter can be swapped when discharged

last-mile delivery provider for brands like Dominos, Myntra, Apollo and Fortis, is present in over 700 cities and will be 100% electric by 2026.

Moving up the mobility value chain to three-wheeler e-vans, Zyngo which calls itself India's greenest last-mile logistics provider, operates a 500-strong fleet across 10 cities, and is confident of soon running a 10,000-strong EV fleet. It has wisely tied up with

EVRE, a leading EV charging infrastructure player who has committed to install 5000 chargers so that its fleet is never too far from a battery charging station in every city.

A recent entrant into e-3-wheelers is Altigreen, an Indian start-up founded by former NASA engineer Dr Amitabh Saran. Its vehicles are built on a mobility platform that is 100% indigenous and backed by 25 global



Zypp Electric, a leading EV-as-a-Service agency, is focused on skilling women to ride electric vehicles as delivery partners and hopes to recruit 3000 women in 2022 as part of



Altigreen e-three wheelers are tailored for last mile deliveries

patents. Their flagship, launched in January 2022, is the Altigreen neEV, a cargo vehicle, delivering 150 kilometres on a single charge, and a 53 kmph top speed using an 11 kWh battery. The company saw investment from an interesting quarter this year: Rs 300 crore from Reliance Industries and four venture capital funds.

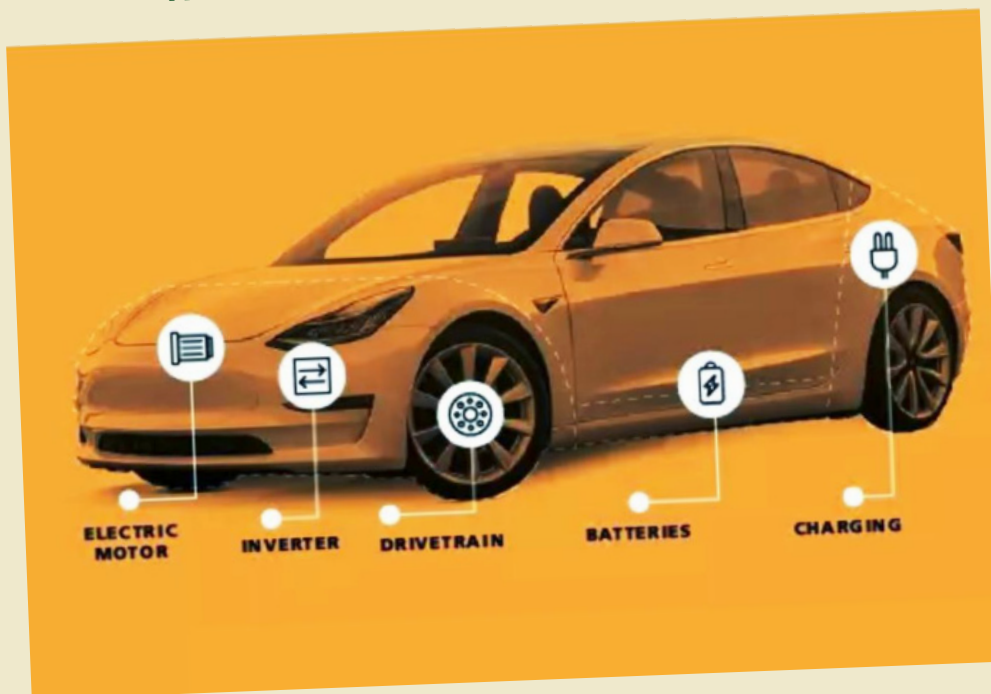
Sodium versus Lithium Batteries

Reliance is addressing an important niche of the EV business – batteries – and is putting its money into an emerging alternative to lithium as the main component of vehicular batteries — sodium. In January 2022, Reliance Industries acquired the UK-based Faradion, a world leader in Sodium-ion battery technology that claims lower cost and higher performance than lithium. Reliance will use Faradion's technology at its proposed energy storage factory, the Dhirubhai Ambani Green Energy Giga Complex at Jamnagar. The world has limited sources of lithium and when there is a global rush into EVs, it is necessary to create national capacity with a viable option to lithium.

The battery is the component that can make or break the EV market. Today the most widely used vehicle batteries are of the Lithium-ion type, consisting of an anode, cathode, separator and electrolyte. The anode is made of carbon, the cathode is metal oxide. The electrolyte, a lithium salt, sits between the two electrodes. It carries the positively charged lithium ions from the anode to the cathode and *vice versa*, depending on whether the battery is charging or discharging. The separator blocks the flow of electrons inside the battery. Investing in sodium along with lithium as raw material for batteries could be critical for India in the race for electric mobility.

Next to batteries, the biggest challenge for EV owners is the availability of charging stations, which is why many EV makers have partnered with charging specialists like the Jaipur-based BattRE, Bengaluru-based Bolt or Charzer, as well as traditional battery players like TataPower, Amara Raja and ABB to ensure that every city has a network of public charging points. Apartment management solution providers like MyGate and Apartment Adda are installing charging stations in housing estates.

How does an electric car or scooter work?



Key elements of an electric vehicle (Image courtesy: edf Energy)

It is generally recognised that three key technologies are needed to drive e-mobility:

- the energy storage system or battery,
- the propulsion system or electric motor and
- the controller or brains of the system.

All electric vehicles from the simplest e-bicycle to the e-scooter/ motorbike to the e-car house these three elements, though the controller will vary in function and complexity.

The battery is the heart of the system and at present, the lithium-ion battery is the preferred type, with some movement towards substituting sodium for lithium. The voltage, charge and storage capacity (measured in kilowatt-hours or kWh) are all critical factors that determine the range and utility of the EV.

The motor provides the propulsion converting electrical energy into physical energy that moves the wheels of the vehicle. Its importance matches that of the battery since its power determines the vehicle's speed, its torque, ability to accelerate, climb slopes, etc.

The control unit is the pipeline or gateway to the motor. In a scooter, the controller interprets the data when the driver pushes the throttle and instructs the motor to deliver more or less energy. It translates brake pressure into a physical slow down or stops. In the new generation smart scooters, the controller has to take driver inputs from the LED touch-screen and execute them.

In a car, the controller acts as an inverter converting power from DC to AC and transmits instructions to the drive train, which sends power to the wheels. In fact, the EV system is simpler and more efficient than the petrol or diesel-driven vehicle.

All EVs include an outlet for charging the batteries. In addition, some two-wheelers are so designed that one can remove the discharged battery and swap it for a fully charged one.

Electric vehicles lack one component of all internal combustion vehicles – an exhaust pipe – because there are no harmful gases to vent out and that is their biggest plus point.



Charging stations set up by myGate for a residential complex

But there is a long way to go before the target of 4 lakh charging stations nationwide is achieved — this is the number required to support the expected spike in EV ownership to 2 million by 2026.

Innovations in EV Technologies

The charging challenge has unleashed Indian creativity. Scientists at IIT BHU in Varanasi in partnership with IIT Guwahati and IIT Bhubaneswar have developed a new technology that cuts by half the on-board charger cost, eventually reducing the selling price of EVs. Lab-scale development has already been done and commercialisation is in progress.

Tailoring the EV for niche markets has provided another challenge. Forest guards have been using petrol motorbikes for years, but the noise scares away animals (and poachers). The e-bike overcomes this problem. Students of the National Institute of Technology, Surathkal, have created the VidhYug 4.0 e-bike for forest surveillance. In addition to silent operation, it has a headlamp that can be detached and used as a searchlight. It comes with a built-in solar charger as charging stations can't be placed in the forest and has a range of 75 km on a full charge.



Gursaurabh Singh with a bicycle he retrofitted to work as an e-bike

From a startup in Punjab comes a retrofit that illustrates the Indian capacity for frugal innovation. Gursaurabh Singh, founder of Druv Vidyut has developed a fixture that can turn a bicycle into an electric cycle within minutes, by engaging with the sprockets of the chain wheel. The video of his invention has become a nationwide YouTube sensation, with multiple Whatsapp forwards.

The electric vehicle is a worldwide work-in-progress, with one difference: this time, India's huge potential market, the national mission to go green in transportation and the



The ASKA flying e-car...a Tech Mahindra partnership

hundreds of innovative EV startups, all ensure that the country will set the agenda and lead the trend, rather than follow a road map set by earlier revolutions like Internet and cellular phones.

And what of the future? In late February 2022, Tech Mahindra announced a partnership with a California (US)-based company, ASKA, a pioneer in electric “drive & fly” which developed a 4-seater electric vehicle that one can drive like a car, then take it up vertically to fly like an aircraft. It runs off batteries but has a range extender to charge the batteries while in flight, to give a flying range of 400 km on a full charge. Tech Mahindra will collaborate with ASKA on the engineering design aspects, which will ensure that it has a role in shaping the end product.

Ten years ago, something like this would have remained the stuff of James Bond movies. Today, it seems very doable—with Indians joining in the doing of what could well be the Next Big Thing in urban electric mobility.

////////////////////////////////////
Mr Anand Parthasarathy is Editor, IndiaTechOnline.com.
Address: MG 601, Magnolia, Golden Blossom, Whitefield
Road, Kadugodi, Bengaluru-560067.
Email: anand@indiatechonline.com

Quantum Frontier Mission



Quantum Enabled Science & Technology (QuEST)

Dr K.R. Murali Mohan

Scientist-G & Head
Interdisciplinary Cyber Physical Systems
Division
Department of Science & Technology (DST)
Ministry of Science & Technology,
Govt of India
Email: krmm@nic.in

Dr Rajeev Sharma

Scientist F
Frontier and Futuristic Technologies
(FFT) Division
Department of Science & Technology
(DST)
Ministry of Science & Technology, Govt of India
Email: rajeevsharma@nic.in

THE Department of Science & Technology (DST) Mission on Quantum Technology is aimed at ramping up R&D in this emerging field. The Mission promises to grow strategically and economically, in a calibrated manner to ensure that the nation reaches, within a span of ten years, the goal of achieving the technical capacity to build Quantum Computers and Communications Systems comparable with the best in the world, and thus earn a leadership role.

The initial three-year period of this mission lays emphasis on building devices, applications and human resources directed towards this goal. During this phase, the researchers involved are targeting to make quantum processors and logic gates, quantum light sources, single-photon detectors, quantum sensors and imaging devices, quantum memories, improved quantum clocks and also demonstrate quantum key distribution and entanglement of distant qubits.

The research in the Quantum field would lead to the development of Quantum Computers, Quantum Communication, Quantum Key Distribution, Cryptography and Cryptanalysis. Quantum computing, the next generation computational paradigm, has many applications like drug discovery, nuclear research, space applications, numerical weather predictions, aerospace engineering and many advanced science & engineering areas. Advancements in Quantum Communication and Cryptography hold the promise of providing an edge in safeguarding our critical communication networks, protect our critical infrastructure, financial networks and services. Technology development in both fibre-based and free-space communication technologies are envisaged in this initiative.

As a pilot before the Quantum Mission, DST initiated an R&D Scheme called Quantum Enabled Science & Technology (QuEST) to develop core expertise in the development of Quantum mechanics so as to realise Quantum Computers, Quantum Communication and Quantum Key Distribution (QKD). The programme was initiated in 2018-19.

This scheme evolved through a National Network Programme involving all stakeholders and experts in the field. Through a national call and selection process initiated by the DST, 51 scientific proposals were chosen in the following four thematic areas:

- (i) **Theme-1:** Quantum Information Technologies (QIT) with Photonic Devices
- (ii) **Theme-2:** QIT with nitrogen-vacancy and magnetic resonance
- (iii) **Theme-3:** QIT with ion-trap and optical-lattice devices
- (iv) **Theme-4:** QIT with superconducting devices and Quantum Dots

There were four major objectives:

1. Development and demonstration of quantum computers
2. Development and demonstration of quantum communication & cryptography with satellite and fibre-based technology
3. Development of quantum-enhanced and inspired technology
4. Development of advanced mathematical quantum techniques, algorithms and theory of quantum information systems.

And the expected outcomes are:

- Development and demonstration of 8-Q-bit quantum computers, communication (Fiber & Free space) & cryptography.
- Development of application-specific quantum algorithms.
- Development of advanced mathematical quantum techniques, algorithms and theory of quantum information systems.
- 100 PhD's in the Quantum field, training to 2000 Undergraduate, Post Graduate and Scholars in advanced algorithm and application development using quantum systems.

Quantum Mission – Current Status

Following are the theme-wise key highlights and developments under the QuEST Programme:

QuEST Theme-I “Quantum Information Technologies with Photonic Devices”

QuEST Theme-I has 24 research projects running at 17 top research institutes of the country. Quantum Information Technologies with Photonic Devices is currently a very active area of research. It focuses on performing quantum information and quantum communication tasks using photons. In addition, this theme studies the foundations of quantum mechanics in general and quantum entanglement in particular in order to explore novel quantum information applications.

In Theme-I overall very good progress has been achieved. Nearly 120 publications have come out of Theme-I. The Website for Theme-I has been launched: <http://210.212.36.85/quest>.

Some key highlights:

- Free space QKD for 200 meters using BB84 protocol and preparation of entangled photon source achieved.
- The relevant integrated photonic devices are being built.
- Single-photon detectors and RF transceiver boards are to be fabricated and tested. Integrating TRNG, quantum transmission, and post-processing for final key transfer
- Femto-second laser installed and home-built coincidence counter is functioning.
- Achieved second harmonic generation efficiency of 30%
- Designed an integrated quantum optic circuit using silicon photonics for QKD and completed the 1st level classical experiment.
- Realizing Robust Authentication and Fast classical QKD post-processing completed.
- Good Progress in Experimental random number generator and Development of Hacking strategy.
- Pump beam with arbitrary partial coherence realised and completed experimental realization of quantum imaging.
- 50% Classical linear and non linear optical properties characterization completed.
- New theoretical protocol for remote state preparation is designed.
- Several protocols developed which use contextuality.
- Progress in quantum heat engines like quantum batteries and quantum refrigerators.
- Percolation of quantum states in networks with defects has been modeled, developed two schemes to efficiently

build quantum communication network in different geometries.

- Two variants of self-testing protocols proposed and one realized experimentally.
- New quantum communication protocols proposed involving recycling of single-copy entanglement. Effect of coherence on entanglement studied.

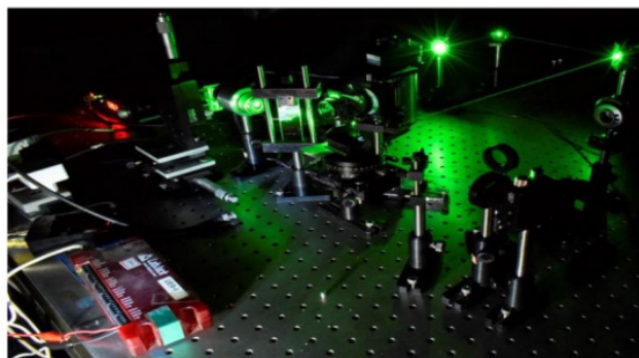
QuEST Theme 2: Quantum Information Technologies (QIT) with nitrogen-vacancy and magnetic resonance

- Quantum computation with NMR & solid-state qubits like Nitrogen/Silicon vacancies:



Omega resonator for NV center fabricated at IISER Kolkata

- Microwave resonators are fabricated and characterised



ODMR setup at IIT Madras

ODMR facilities setup/being upgraded

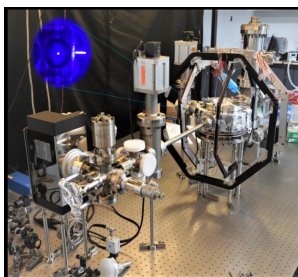
- Photonic crystal cavity is designed, fabrication is underway
 - Charge-state-selective mapping of NV centres
 - NMR characterisation of temporal correlations and violation of Peres-Mermin inequality
 - Explored uncertainty regions for a given pair of non-commuting observables
- Generation & characterisation of entanglement
 - NMR demonstration of entanglement localisation via classical mediator
 - Proposed an interferometric scheme to test the separability criterion
 - Proposed optimal schemes for Gaussian state/process tomography

3. Development of decoherence mitigation strategies
 - Model Hamiltonians with disordered/quasiperiodic potentials have been set up
 - Coding developed to characterise localised/delocalised phases
 - Proposed a method to detecting environmental correlations via correlated spectroscopy
4. Development of quantum sensors based on nitrogen vacancy centers
 - Demonstration of high sensitivity NVC magnetic field sensor with temporal imaging
 - Developed micro-PL setup with confocal scan
 - Isolated nanodiamonds and measured its emission spectra along with confocal scan
5. Development of quantum enhanced and quantum inspired technologies
 - Demonstrated trapping & rotational control of nanodiamonds
 - Demonstration of population inversion in NV diamond for masing applications

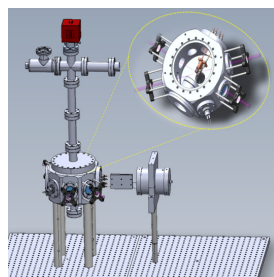
QuEST Theme 3: Quantum Information Technologies with ion-trap and optical-lattice devices: Ultra-cold & trapped atoms/ions

Major Developments:

- Initiation of four state-of-the-art ultracold atoms/ions based quantum simulators, sensors and quantum clocks' experimental setups at IISER-Pune, IUCAA Pune, IIT Roorkee and IIT Guwahati to leverage the Indian quantum mission.
- QuEST facilitated a balanced platform to create synergy between experimental & theoretical groups in India.
- Knowledge creation in theoretical quantum information processing, quantum computing and error correction for direct applications in ultra-cold atomic/ionic platforms.



Strontium Atomic Clock and Quantum networking system at IISER-Pune



Design of the Ytterbium-ion trap quantum clock at IUCAA

QuEST Theme-4: Quantum Information Technologies with superconducting devices and Quantum Dots

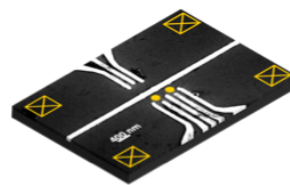
Theme-4 of the QuEST is related to Quantum Technologies with superconducting & quantum dot devices. These represent some of the most promising technologies for developing a practical quantum processor.

Progress has been made in setting up the hardware platform, developing new techniques for testing and characterisation,

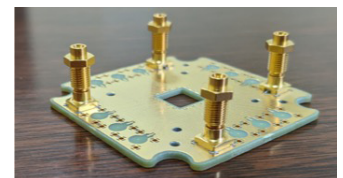
and some initial demonstrations. In addition, strong theoretical support has led to the development of new ideas, methods for validation of the experiments, and collaborative efforts to push the state-of-the-art in different areas of superconducting and semiconducting quantum technologies. These efforts have led to about 9 publications so far. About 14 JRFs and 3 RAs have also been hired.

Key highlights:

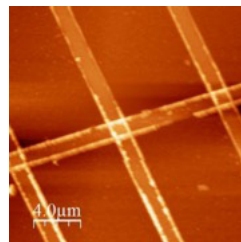
- **To develop quantum processors up to 4 qubits using superconducting circuit and semiconductor quantum dot technology**
- Device fabrication in superconducting and semiconducting qubits.
- Basic characterisation of semiconducting q-dots.
- Novel ring resonator-based coupling for enhanced connectivity in superconducting qubits. Preliminary demonstration with 4-qubits.
- Superconducting lumped element resonators for readout fabricated and characterised.
- Microwave packaging for 2D/3D devices.



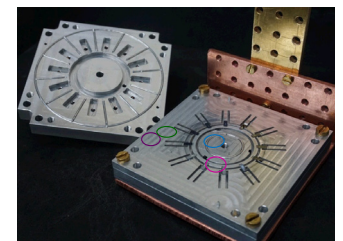
Ring resonator coupler for superconducting qubits



2D microwave packaging for superconducting qubits



Oxide insulator test for quantum dots



Gate-defined double quantum dot system

- Optimal control for improving gate fidelity.
- **To develop algorithms that demonstrate quantum advantage in small quantum processors**
- Characterisation of entanglement as a resource
- Using Grover's algorithm on NISQ quantum devices
- **To develop software tools for efficient mapping of quantum algorithms to quantum hardware**
- Machine learning for the design of quantum algorithms
- **To develop detailed theoretical understanding of the information processing and computing capabilities**
- Modelling of molecules strongly coupled to a cavity as an open quantum system addressing singular behaviour in first-order quantum master equations.
- New kind of monogamy relations for multi-qubit systems to understand how entanglement is distributed in multipartite scenarios.
- Quantum thermal machines for entanglement generation in steady-state.



Digital India Mission

Siddhey Shinde

Young Professional, NITI
Aayog, Govt of India
Email: siddhey.shinde@nic.in

Juhi Jain

Young Professional, NITI
Aayog, Govt of India
Email: juhijain.aim@nic.in

Catalysing Change, Accelerating National Development

FROM groceries being delivered at a click, to ticket bookings, transfer of money, and innumerable services being offered online, the ongoing digital revolution is there for all to see. Leveraging the talent and vision of the young citizens of the nation, the Digital India initiative has further put the nation on a rapid trajectory of economic growth, innovation and entrepreneurship.



Image credit: digitalindia.gov.in

Launched in 2015, the vision of the Digital India mission is to promote inclusive growth in the areas of electronic services, products, manufacturing, and job opportunities. This means an umbrella structure encompassing diverse digital infrastructure being set up for socio-economic growth as well as for service delivery of various initiatives launched by the government. The mission also has a key focus on digital empowerment through the digital literacy of the citizens. And so

far the progress has been stupendous, both in terms of establishment as well as in terms of usage.

Digitising India

According to the Unique Identification Authority of India (UIDAI), 129 crore residents of India possess Aadhaar. As of April 2021, there are ~60.09 million registered DigiLocker users in India and >171.51 lakh registered members on MyGov. As of 2020, there were ~146,872 service-ready Gram Panchayats, 255,798 active Common Service Centre (CSC) IDs and 687 districts had CSCs in India; India Post Payments Bank (IPPB) enabled >1.36 lakh post offices to provide banking services, including access to every Aadhaar-linked bank account, at the customer's doorstep, resulting in ~2.5x increase in rural banking infrastructure, and ~572,551 villages were provided with mobile and internet connectivity. India's public Wi-Fi hotspots were estimated to increase from 0.3 million in 2019 to 2.1 million in 2021, according to DigiAnalysis. In 2020, the government launched PM eVIDYA, a programme for multimode access to digital/online education.

Clocking over 4.65 billion transactions in volume, the Unified Payment Interface (UPI) volume achieved all-time high transactions in January 2022. Further, the recently launched UPI123Pay for feature phones will allow payments over apps, missed calls, interactive voice response, even

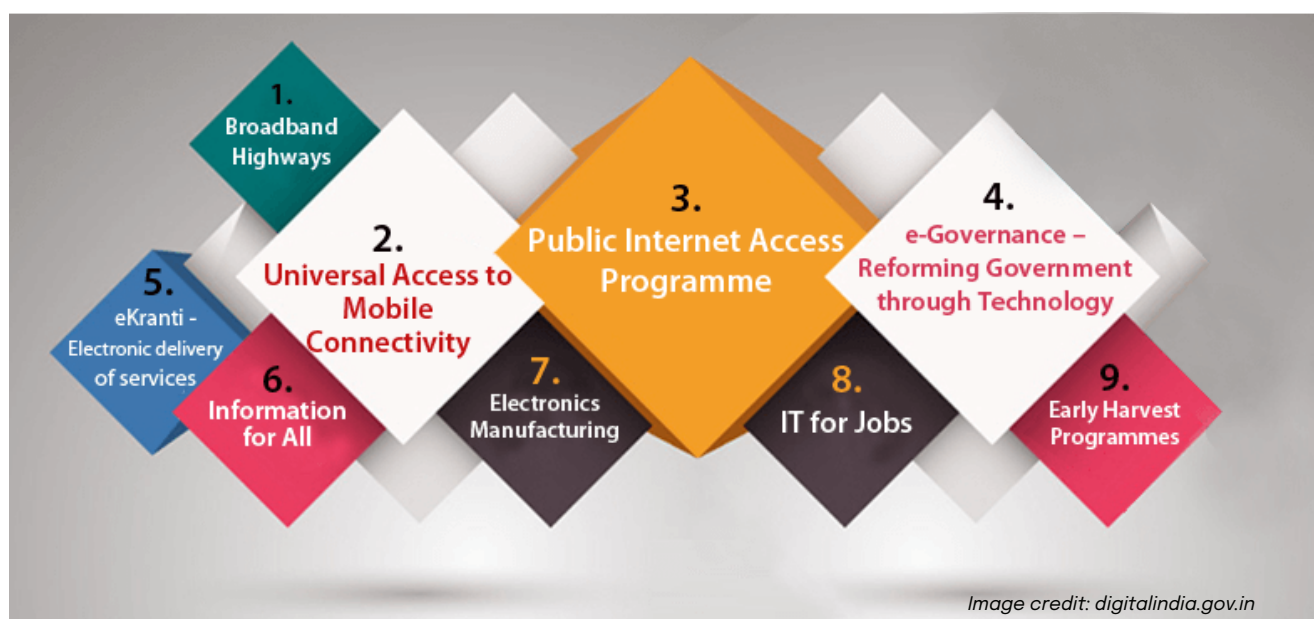


DigiLocker

Your documents anytime, anywhere

Image credit: digilocker.gov.in

using proximity sound. The government uses JAM's (Jan Dhan-Aadhaar-Mobile) direct benefit transfers for ~317 services. In FY21, it conducted 2.6 billion transactions, transferring >US\$ 46 billion to beneficiaries. As of 2019, 23,097,324 beneficiaries were registered; of these, 13,491,306 beneficiaries were certified. As of February 2021, 420 e-Hospitals were established across India. In FY21, NISHTHA Phase II was launched at the secondary level to customise modules for online delivery. And as per the Union Budget 2021-22, under the NISHTHA training programme, ~5.6 million teachers will be trained in FY22.



Pillars of Digital India

Powering these are the nine key pillars of the Digital India programme, which act as the real strength of the digital India infrastructure and connectivity. Each of these is a complex programme in itself, and stands true to the collaborative and integrative approach of governance through convergence and synergies, across multiple Ministries and Departments.

- **First Pillar:** Broadband highway in rural areas and urban areas for agriculture to banking, e-governance, e-Panchayat and other important services delivered through communication infrastructure of the National Optical Fibre Network (NOFN) and Virtual Network Operators. National Information Infrastructure (NII) would integrate the network and cloud infrastructure in the country to provide high-speed connectivity and cloud platform to various government departments up to the panchayat level.
- **Second Pillar:** e-governance which includes re-engineering of the processes using technology to make the delivery of government services more effective and faster by reducing the paperwork. This will be done using the Mobile Seva platform, Application

Programming Interfaces (API) and middleware such as National and State Service Delivery Gateways (NSDG/SSDG).

- **Third Pillar:** Focuses on network penetration and filling the gaps in connectivity in the country through mobile phones. This involves bridging the gap by providing mobile phone coverage to uncovered areas, especially in the North East.
- **Fourth Pillar:** E-kranti to provide good governance through integrated services, rather than individual services.
- **Fifth Pillar:** Public Internet Access Programme, which has two sub-components – Common Services Centers (CSCs) and Post Offices as multi-service centres. Under the CSC, 2.5 Lakh Gram Panchayats will be covered to maximise the delivery of e-Services to the citizens. Also, a total of 150,000 Post Offices are proposed to be converted into multi-service centres.
- **Sixth Pillar:** Open Data platform to facilitate the proactive release of datasets in an open format by ministries/departments for use, reuse and redistribution. This online hosting of information, as well as documents, would

facilitate open and easy access to information for citizens.

- **Seventh Pillar:** Focuses on providing training to youth in the skills required for availing employment opportunities in the IT/ITES sector. It includes setting up of centres/BPOs to facilitate ICT enabled growth. It also includes training five lakh rural workforce as Telecom Service Providers (TSPs) and as service delivery providers.
- **Eighth Pillar:** Manufacturing of electronics against the target of net zero imports. It includes the production of FABS, Fabless design, Set-top boxes, VSATs, Mobiles, Consumer & Medical Electronics, Smart Energy meters, Smart cards, micro-ATMs, etc. within India promoted by several policies, subsidies and schemes including the PLI scheme and NPE.
- **Ninth Pillar:** Early Harvest Programme consisting of projects to be implemented within a short timeline such as biometric attendance, Wifi in all universities, secure email within government, e-books in schools, etc. These initiatives are designed to deliver impact in the minimum possible time.

New Services for Digital India



The impact of digital technologies is best seen in our largest cities where the integration of these technologies with various aspects of human life is at the highest. Historically, the agglomeration and growth of these cities were due to the ease of access to a wide range of key services in and around the cities. With digital technology, this ease of access has improved further. For the most aspirational regions of New India, the true value proposition of Digital India lies in the platform it creates for the delivery of key services that are necessary for the developmental goals of the nation.

Education

The delivery of educational services over digital platforms has been a longstanding developmental goal. Before the COVID-19 pandemic, this model was primarily used for co-curricular studies in India, with growing adoption largely in higher socioeconomic strata of urban regions. While there had been several isolated projects that found some success in digitising higher education, the use – and more importantly, acceptance – of this model for primary and secondary education only began following the first

wave of the pandemic. Many schools and universities are now open to the use of video conferencing applications as a mode of delivering instruction. (Muthuprasad *et al.*, “Students’ perception and preference for online education in India during COVID-19 pandemic”, 2021, *Social Sciences & Humanities Open*).

Education in New India must build on this foundation and enable wider educational experiences and services over digital technologies. Building on the goal of PM eVIDYA, which offers primary to higher secondary education over DTH channels, similar high-quality educational content can be delivered over the internet and mobile applications. Initiatives like ePathshala, which is an app that provides digital textbooks, can also be very useful in higher education where there is a wider range but lower access to textbooks. Further, interactive virtual labs for science and mathematics can significantly improve crucial critical thinking skills. In addition to this, programmes focused on women education which incorporate skill development, delivered digitally, are needed for improving female literacy.

Healthcare

Another developmental priority is healthcare services, where digital technologies can play a revolutionary role. There exists an acute shortage of specialists in Primary Healthcare Centres (PHCs) and community healthcare centres (CHCs), especially in regions like the Aspirational Districts, which makes access to modern healthcare difficult. This issue is exacerbated by low post-treatment and post-operative care among patients, who find additional follow-up appointments tedious.

Similarly, according to information collected by the authors from Aspirational Districts in India, *Anganwadi* workers report that pregnant women and new mothers show good responses when present but have a poor follow-up after they migrate, usually for seasonal employment. A majority of the challenges around healthcare in India revolve around access and awareness.

It is important to note that many such challenges have been resolved in the developed regions of the country using digital technology solutions. Models that have been successful there can be adapted to the requirements here. For instance, a mobile-based application that enables people to set appointments, chat, or video-consult their nearest PHC and CHC for non-critical appointments can greatly improve follow-up care. The same application can enable access to specialists all across the country or even a second opinion, and improve the dissemination of verified information on vaccines. This also serves to digitise patient records and improve access to critical information for medical professionals.

Financial Inclusion

There is ample evidence linking financial inclusion to improved developmental outcomes, and a crucial step in overcoming poverty is universal banking. India’s banked population stands at 80% — double of what it was a decade ago — but despite this, nearly 200 million people in India still do not have a bank account, of which 56% are

women. (*Global Findex Report 2017*, World Bank).

India has made strides in improving access to financial inclusion initiatives like Jan Dhan Aadhaar Mobile, Direct Benefit Transfer, etc. but the usage of these facilities still remains low. (*Financial Inclusion Index 2021*, RBI). Further, access to lending facilities, which is critical to economic growth, is far lower due to a lack of credit. While the nationwide transition to a cashless system is underway, through UPI and RuPay like initiatives, the adoption reduces drastically in rural regions where such systems have not been adopted by the commerce ecosystem.

Solutions for India need to be designed in the Indian context, leveraging our strengths to meet our challenges. A good example of this is the introduction of UPI for feature phones, launched by RBI with the expectation to bump up digital adoption. The use of payment banks has seen wide adoption in India but an unexpected consumer behaviour was the use of these payment banks (like IPPB) to 'keep and save' money, especially in rural areas.

Although the payments bank model was originally conceptualised to be without credit, its success and consumer behaviour present an opportunity. Expanding the model through incremental services like savings accounts and microlending would create a path to formal banking and credit worthiness, while also improving trust in the system. The adoption by the commerce ecosystem, however, will require special attention.

Commerce & Logistics

While quality education and healthcare are certainly essential to development, the most visible form of development remains economic growth. Put simply, when people see bigger markets, more products, more buyers, and more money, they are able to 'see' the development. This kind of development is driven almost entirely by commerce and logistics, which in turn is driven by the industry of the region. (Pradhan, R.P & Bagchi, T.P., "Effect of transportation infrastructure on economic growth in

India: the VECM approach", 2013, *Transportation Economics*). Digital technologies can play an enabling role here but also require a conducive market environment and industrial activity.

There has been some progress in increasing commerce through initiatives like e-Mandi, a platform for agricultural products. A low-hanging fruit would be the creation of a unified e-commerce platform, which enables smaller businesses, craftsmen, and logistics service providers to offer their products and services to a wider audience. Here, it is important to note that immediately visible access to products and services improves the market environment, driving in more business and industrial activity. Similarly, a campaign to increase the adoption of a cashless system will increase the acceptance of e-commerce.

Agriculture and Employment

Although the largest occupation in rural India remains agriculture and allied sectors, the practices therein are predominantly conservative. Despite longstanding efforts of the network Krishi Vigyan Kendras across the nation, providing a host of informational and training services, it has been difficult to drive a shift to sustainable agricultural practices. (Sahu P, "Sustainable Agripreneurship", March 2022, *Kurukshetra*). Similarly, access to quality seed has been subject to regional markets and state seed corporations. Given the limited employment options, these regions also see high rates of seasonal migration for employment.

Here, the digitisation of services through initiatives like e-Krishi Kendra could work towards creating a larger network of farmers, agri-businesses, and agricultural experts. The next step should include offering digitised soil and water-testing services, geolocation specific climate updates with relevant guidance, and digital plant health consultations. This will also nudge farmers towards modern agricultural practices.

Similar to the Unified Mobile Application for New-age Governance

(UMANG), a portal should be opened for employment opportunities, also offering vocational training as per the needs of the regional industries. This will enable better support systems for seasonal migrants and their dependents, while also enabling upskilling and financial growth.

An Opportune Moment

One of the largest barriers to service delivery and development in remote and rural regions is the lack of connectivity. Consequently, early efforts were distributed, some geared towards the provision of such connectivity to deliver tele-education and telemedicine, while others focused on e-governance and service delivery. The Digital India mission brought all of them under one roof, slowly increasing the rate of adoption.

Until before the COVID-19 pandemic, this was still considered a long-term goal. However, as a result of the pandemic and the nation's response to the pandemic, there has been a seismic shift in the way of life and business. Today, there is increasing adoption of online education, remote work practices, e-marketplaces, online banking, remote medical consultations, and even e-governance. Digital technologies have permeated our lives.

This shift has created two conducive conditions to implement reforms that will enable the achievement of the vision of the Digital India mission. First, this tidal shift has attracted the attention of businesses and investors alike, who are now looking for opportunities to break into these new markets. Second, this shift will also frame the new social norms around the use of digital technology in everyday life, which will directly affect the digital literacy of the average citizen.

These two conditions offer an opportune moment to accelerate the nation's development through the delivery of key services over a digital platform. This is the way for Digital India to maximise its impact as a platform for our society in New India.



National Hydrogen Mission



Can Green Hydrogen be the doorway to the sustainable energy transition?

Ansuman Dash

THE Olympic flame of the 2021 Tokyo Olympic Games was different in nature from all its previous versions. For the first time in the history of the Olympics the flame was sustained by hydrogen, produced by the electrolysis of water using solar power and not by hydrocarbon gases depicting the promise of clean fuel and a carbon-free future.

The potential of hydrogen fuel can serve two goals of the UN Millennium Development Goals – ‘affordable & clean energy’ and ‘climate action’. Hydrogen is a zero-carbon emission fuel although it is not yet an affordable fuel today.

In view of this, on 15 August 2021, the Government of India launched the National Hydrogen Mission (NHM) under the Ministry of New and Renewable Energy (MNRE). The NHM has the objective of sanctioning pilot projects, research & development, policies and regulations for green hydrogen production and distribution with a proposed budget of Rs 800 Crores for the next three years. To encourage the green hydrogen industry to meet the target production of 5 million tonnes of green hydrogen by 2030 and to make India a green hydrogen hub the NHM announced several measures under its new green hydrogen policy on 17 February 2022. This announcement is a significant step towards the sustainable energy security of India.

Hydrogen as Fuel

The hydrogen gets a ‘green’ prefix when it is produced from renewable or carbon-neutral green energy sources such as wind power or solar power. Based on the process of hydrogen extraction, the other two types are called grey hydrogen and blue hydrogen. Grey hydrogen is the one in which hydrogen is obtained directly from natural gas and the by-product carbon dioxide is emitted into the atmosphere. In blue hydrogen, the hydrogen fuel is extracted in a similar way but the carbon dioxide is stored for future use instead of emitting into the atmosphere.

In order to meet zero-carbon emissions by 2050 as per the Paris agreement and to combat the challenges of global warming and climate change, gradual shifting to carbon-neutral energy sources from fossil fuels is essential. “Green Hydrogen” can play a vital role in this energy transition. Just like getting cooking gas in LPG cylinders, the future generation can get energy in the form of green hydrogen in similar containers. The excess solar or wind power during off-peak hours can be utilised for electrolysis of water and hydrogen produced can be reserved in a container for future use. This sustainable energy box or container will accommodate the hydrogen as well as the medium for conversion of this hydrogen into electricity like a fuel cell. Just like buying items in supermarket one can buy this portable energy box and light up her or his house like any plug-and-play device. Of course, this method of getting electricity at home without any wires is theoretical as of now but is a next-generation possibility.

In a typical fuel cell, hydrogen gas is allowed to react with oxygen to release energy with water. This process is done in a controlled manner by utilising platinum catalyst. Hydrogen gas is allowed to pass through the anode of the fuel cell; as it strikes the platinum catalyst, also known as Proton Exchange Membrane (PEM), it splits into hydrogen protons and electrons. The protons pass through to the cathode but electrons are forced to flow through an external circuit to form an electric current. On the other side of the fuel cell, oxygen enters the cathode and combines with the hydrogen proton and returning electrons from the external circuit to form water – basically the reverse process of electrolysis.

Water being the only end product makes hydrogen fuel a zero-carbon fuel. Hundreds of fuel cells can be stacked together to produce a significant quantity of electricity. Fuel cell has earlier been used in spacecraft. It has also been tested to replace the internal combustion engine in the automobile sector.

Hydrogen can be stored in cylinders and transported for the end user's access. Thus, electricity can be kept reserved in the form of hydrogen for domestic use as per the requirement. And so, energy in the form of green hydrogen can provide a great energy storage option unlike energy in AC electricity form which has no possibility for storage and in DC electricity where the requirement of huge batteries for a large amount of energy storage is a significant drawback.

Renewables like solar or wind power are incapable of industrial high energy intensity applications like steel or aluminium manufacturing. However, hydrogen stacked and stored after being produced by those renewables is capable enough for the same industrial purpose.

Since hydrogen doesn't typically exist by itself in nature it must be obtained from compounds that contain it. The electrolysis process of hydrogen production requires large

National Hydrogen Mission

The Government of India's National Hydrogen Mission (NHM) aims to encourage the green hydrogen industry to meet the target production of 5 million tonnes of green hydrogen by 2030. To make India a green hydrogen hub the NHM announced various measures under its new green hydrogen policy on 17 February 2022. The major policies or incentives can be summarised as:

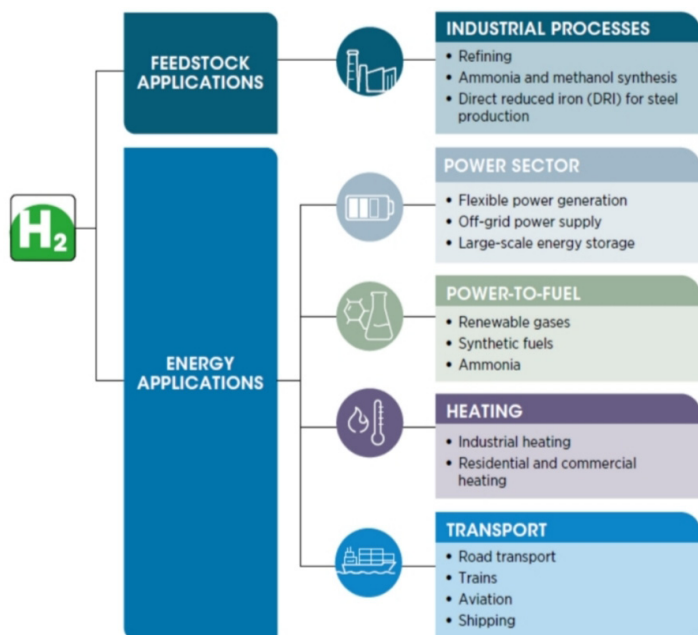
1. The manufacturers of Green Hydrogen may purchase renewable power from the power exchange or set up renewable energy capacity themselves or through any other developer, anywhere in India. They can bank any unconsumed renewable power, up to 30 days, with a Distribution Company and take it back when required.
2. Distribution companies can also procure or supply renewable energy to the manufacturers of Green Hydrogen in their States at concessional prices which will only include the cost of procurement, wheeling charges and a small margin as determined by the State.
3. Waiver of inter-state transmission charges for a period of 25 years will be allowed to the manufacturers of Green Hydrogen for the projects commissioned before 30 June 2025.
4. Manufacturers of Green Hydrogen shall be allowed to set up storage bunkers near Ports for storing Green hydrogen to export or to use by shipping. The land for the storage for this purpose shall be provided by the respective Port Authorities at applicable charges.
5. The manufacturers of green hydrogen and the renewable energy plant shall be given grid connectivity on priority basis without any procedural delays.
6. For ease of doing business, MNRE is to set up a single portal for carrying out all the activities including statutory clearances in a time-bound manner.

The timely implementation of the above policies can facilitate the energy transition from fossil fuel to green hydrogen fuel and reduce the country's dependency on crude oil imports. The first energy revolution occurred after the invention of the steam engine where steam was the energy carrier. The second energy revolution occurred after the discovery of electricity as the energy carrier. The next energy revolution could be possible by green hydrogen fuel as the energy carrier.

The trend of reducing tariffs on renewable energy will surely make way for environmental friendly hydrogen fuel. The most important advantage of hydrogen fuel is that it has three times the energy density per mass as methane or gasoline which can make its transportation cost-effective. However, being the smallest element, it has a higher risk of leakage.

The other challenges right now are that the big electrolyzers and the plentiful supplies of renewable electricity still come at a significant price. Storing and transporting this highly flammable and explosive gas is never so easy and will require expert handling of the material.

Mr Ansuman Dash is an electrical engineer in NTPC Ltd. and presently posted as Manager (Projects) at NTPC Bongaigaon, Assam. Address: Plot No. 215, Sishupalgarh, Bhubaneswar-751002. Email: dashansuman7@gmail.com



Credit: International Renewable Energy Agency [IRENA]

amount of electricity which is so far cost-effective. The per-unit cost of thermal power production stands more than Rs 3 today. The solar and wind power production in India now costs around Rs 3 and Rs 5 per unit today, respectively.

For producing 1 kg of hydrogen by the electrolysis process around 39 Kilowatt-hour of electricity is needed considering no energy losses in the system. Considering 60% efficiency of the system (39/0.6) 65 KWH or 65 Units of energy is required. And the typical fuel cell can produce around 33 KWH of energy from 1 kg of hydrogen fuel. Hence with the available technologies, green hydrogen is not much economical, rather suffers a loss of 50% of energy between production and output.

In the coming years, new technologies and better infrastructure can make this alternative production method of hydrogen cost-competitive. For instance, the central PSU under the Ministry of Power, NTPC Ltd., recently tested the viability of the hydrogen fuel cell bus between New Delhi and Jaipur as well as in Leh.

"RESILIENCE, PERSEVERANCE AND PERSISTENCE ARE IMPORTANT IN RESEARCH."

- Prof. Chennupati Jagadish

Meher Wan



Meher Wan: Congratulations for being elected as the 20th and the first Indian origin President of the Australian Academy of Science.

Prof. Chennupati Jagadish: Thank You.

MW: I am curious about your process of recognizing a research problem and devising a method to solve it. For instance, how did you get the idea of making possibly the smallest lasers?

CJ: Generally, I look for problems that are complex, challenging and impactful. Also, problems that are long term in nature as these will lead to high impact research outcomes. I am always looking at the big picture in science and engineering.

Prof. Chennupati Jagadish is distinguished professor of physics at the Australian National University. He is currently heading the Semiconductor Optoelectronics and Nanotechnology Group which he established in 1990. He is the Convener of the Australian Nanotechnology Network and Founding Director of the Australian National Fabrication Facility (2007-2020). In 2016, the Australian Government bestowed upon him 'Companion of the Order of Australia' honour which is the highest honour in Australia given to a citizen. He has been awarded other prestigious awards including 'IEEE Pioneer award in Nanotechnology-2015' and 'Walter Boas Medal' from the Australian Institute of Physics-2013. He was elected as the 20th president of the Australian Academy of Science recently. He is the first Indian origin Australian to hold the prestigious post. Dr Meher Wan got an opportunity to interview him recently.

We have been working on lasers for more than 20 years. We made some of the high power lasers with world record output power (980 nm); these lasers are used in optical fiber communication systems for pumping of erbium doped fiber amplifiers. Since my research interest and background is optoelectronics, it is a natural progression for us to move from microlasers to nanolasers.

There are many challenges at the nanoscale as light-matter interaction changes. So, we want to make use of materials at the nanoscale and their properties to create nanolasers. Smaller the lasers faster they can be switched on and off and also consume less energy. However, they produce less output power but for applications such as sensors the power generated by these lasers is sufficient. One needs to choose the right laser for the right application.

MW: What was the motivation to work in photonics and nano-lasers?

CJ: Photonics is the technology of light. We get 90% of information through vision and light. During my childhood I had very little light as I studied in front of a kerosene lamp in a small village in India. Developing light technologies changes the lives of people. For example, optical communications in combination with wireless communications led to internet and changed the way we live, communicate and interact with each other. Nano-lasers (and single photon sources) are next generation of light emitters which will play an important role in highly secure quantum

communications. These lasers are also useful in point of care diagnostics, bio-imaging, etc.

MW: *You have had a very long journey from a very small village of Andhra Pradesh to being an internationally renowned scientist. How did your initial struggle for education in the village empower you?*

CJ: When you have to live without electricity and walk for 5 miles (8 km) to go home, even during my PhD in Delhi in the 80s, it teaches you tenacity, persistence and perseverance. I come from a farming family though my father was a school teacher who quit his job when I was 10 and returned to farming. Farmers are naturally optimists and have tenacity, persistence and perseverance. People always tell me I work hard; I tell them that you don't know what hard work is till you see farmers in the villages and how hard they work. I feel fortunate that I had seen this from my childhood and I always wanted to make use of the opportunities in front of me to the fullest extent though I goofed up during my teenage years, which is also part of life. My philosophy has always been never give up and keep trying.

MW: *You started your career in academics with teaching in a college in Delhi. What motivated you to start again in research with more energy and focus?*

CJ: I enjoyed my teaching at Sri Venkateswara College in Delhi for 3 years. I used to teach in the morning at the college and travel to Delhi University Physics Department to do my research in the afternoons. S.V. College is a great college with bright students and committed academics and staff. I realised that I enjoyed both research and teaching and being only a teacher was not sufficient for my curiosity and desire to do research. By the way, my students whom I taught in S.V. College still keep in touch with me even after 35 years.

MW: *How do you remember your struggle as a beginner in research?*

CJ: I started applying for post-doctoral fellowships while teaching at S.V. College as I wanted to gain international research experience. In those days there was no internet or email and we used to get magazines such as *Physics Today* or *IEEE Spectrum* by sea mail at the Delhi University Library 3-6 months later. They used to have advertisements for various positions in overseas Universities, without mentioning deadlines. So I would apply for various positions without knowing that they had already been filled up. I have got about 300+ regret letters from all over the world over three years.

Meanwhile, my friend Dr K. Sreenivas (who is a Professor of Physics at Delhi University) returned

from Queen's University (Canada) and encouraged me to write to Prof. David Atherton at Queen's University. I wrote to him and after four months he offered me a contract for two years as a post-doc to work in his group in the field of magnetism, to detect corrosion in oil and gas pipelines using magnetic techniques.

My PhD was in semiconductors and I had to learn from scratch the field of magnetism. He asked me to set up a new experiment, so I did literature search, identified equipment needed, ordered the equipment and built the experiment and started producing good results to write a paper by the end of the first year. In two years, I had 10 journal papers and started getting invitations to give invited talks at prime conferences in the field – I realised our work was making an impact in the field.

Prof. Jim Whitton, in the same Department, one day asked me if I would be interested in a position at the Australian National University (ANU) where Prof. Jim Williams was starting a new Electronic Materials Engineering Department. I told him yes, and after six months later I got an offer letter to join ANU on a two-year contract.

MW: *Being a physicist, how did you get interested in the behaviour of brain cells? Why is it important to understand?*

CJ: This is an interesting story. Nanowires are being explored to study neurons and engineer neurons. A young scientist from JNCASR, Bengaluru, moved to Canberra to join her husband who is working in Earth Sciences. During her PhD she used organic semiconductors to create artificial retinal electrodes. So I asked her to work in my group. We both visited the John Curtin School of Medical Research and spoke to people working in neuroscience. They loved the idea.

We used our nanowires to engineer the neurons and her skills in dealing with neuron cells. The young scientist is Dr Vini Gautam and she is the major driver of this project. She is now a Lecturer in Biomedical Engineering at Melbourne University. Based on her work, Dementia Australia funded us a multidisciplinary project involving multiple universities and scientists from various disciplines including stem cell biologists, neuroscientists, computer scientists and nanotechnologists.

We are learning a lot about the brain; the more you study the brain the more you realise how little we know as it is a highly complex organ and important to understand and develop technologies for addressing neurological disorders faced by the ageing population such as Alzheimer's disease.

MW: *How satisfied do you feel now after such a long and fruitful journey in science?*

CJ: I am highly satisfied with my life and very contented. I have always focused on doing my best and helping others. This turned out to be an enjoyable journey and I love it. Wonderful students, post-docs, young academics, collaborators have enriched my life as it has been great fun working with them all. I have always felt science is fun. Once one is having fun, one never looks back. I feel fortunate to be in science for more than 40 years and still enjoy every day of my life doing science, enabling science, mentoring scientists, communicating science to the public.

MW: *What are the most important unsolved challenges in the field of photonics or nano-sciences for this decade?*

CJ: There are many. For example, energy is still an unsolved problem. How to create efficient energy sources with low footprint on our environment and on our planet. Nanotechnology and Photonics are expected to play an important role in energy generation and storage (e.g. solar photovoltaics, batteries, hydrogen generation and storage, etc.). Water purification for providing clean drinking water both photonics (e.g. UV LEDs) and nanoscience (e.g. membranes) will play an important role. Disease detection and treatment is another area photonics and nanoscience will play an important role in terms of developing point of care diagnostics, targeted drug delivery, etc. All these technologies need to be developed and made affordable to large populations with low impact on the environment.

MW: *We have also heard that you like mentoring students. Can you tell us something about that?*

CJ: It is important for me to help others as so many people helped me in my career. I always enjoyed mentoring youngsters. In order to give back, my wife Vidya and I started an endowment "Chennupati and Vidya Jagadish Endowment" at the ANU to enable students and young scientists from developing countries to visit ANU for 3 months and carry out research. Mainly we had students from India though this year we had one student from Indonesia.

After the success of this programme, the ANU College of Science under the leadership of Dean Prof. Kieran Kirk started Future Research Talents (FRT) programme for students from India to work in both the Colleges of Science covering Astronomy, Biology, Chemistry, Earth Sciences, Medical Sciences, Physics and Science Communication. In 2019, 52 students from India and 1 student from Indonesia visited ANU and carried out research. ANU invests \$300,000 in this programme to support students from top institutions in India. Due to COVID-19, we could not host any student in 2020-22. We look forward to hosting new batch of students in 2023.



Prof. Jagadish with students

(Picture Courtesy: Australian National University)

MW: *How important do you consider the role of scientific administration in improving the state of S&T? Many scientists find it as a distraction to their research.*

CJ: Scientists have the responsibility to share their knowledge with the public so that they can appreciate the value of science and its impact on their lives. Also inspiring the next generation is important and science administration can play an important role. Good people in the right positions can make a big difference in transforming S&T in any country and create opportunities for others. Helping others makes all of us happy. If people get into these positions to improve the system and help others, they will have a fulfilled life. If people take up these positions for their personal ego and title, then it is not going to help anybody including those individuals.

MW: *Any message for young researchers in India!*

CJ: Believe in yourselves, work hard and smart; resilience, perseverance and persistence are important in research – never give up. Develop good communication skills both oral and written form, collaborate and cooperate, network with others, and understand the system and its expectations. India has lot to offer, maintaining positive attitude in life is important whether it is research or any other endeavour. If a boy from a small village in India can receive the highest civil honor from the Australian Government and can become the President of the Australian Academy of Science, sky is the limit for all of you. Good luck to you all.

MW: *Thanks again professor for investing your precious time for this interview. I hope many students and youth will get inspired with your words and journey.*

CJ: Thanks Meher Wan. It has been a pleasure. Good luck.

////////////////////////////////////
Dr Meher Wan is Assistant Editor, *Science Reporter*,
CSIR-NIScPR, New Delhi

2082

Shruti M.



DHUN's door clicked open like it did every day, at 7:00 A.M. The lights in the room turned on. The curtains slid open. Pappa followed, seven minutes later, with a mug of chocolate milk held between his hands, which he carefully placed on her bedside table.

Dhun was fast asleep. And like every morning, pappa snuggled beside his nine-year-old. Dhun wiggled, her subconscious slowly fading into reality. Pappa tickled her, kissed her, tickled her, kissed her. And after about fifteen minutes of the ritual, Dhun opened her eyes and rolled out of her bed.

Pappa handed her the milk, and they both made their way into the living room as the lights in Dhun's room dimmed behind them.

Dhun sat on the sofa, sipping milk, and watching the Big Screen. The Big Screen would normally display all the information about everyone's schedules, the working condition of all equipment in the house, other important reminders, and updates. It kept track of almost everything. It had multiple playlists and everyone's favourite programming. The morning news was on, right now.

Pappa listened to it as he tidied up the living room and made breakfast.

"COVID-19 is a virus, right?" Dhun asked, pointing at the screen.

Pappa came and stood in front of the screen after tossing an eggshell into the compost processor.

"Mental health experts suspect the after effects of 2020, COVID-19 and 2044, TRIC-1 pandemic may still be showing

up in unexpected ways. The government has sanctioned a big budget to study the generational effect of COVID-19 on mental health. Health Minister Aryan Tripathi said

"COVID and TRIC-1 are viruses, right?" Dhun asked again.

"Yes. They were pandemics." He said, turning to her. "Do you know what a pandemic is?"

"Are we having omelette again?" asked Dhun looking past Pappa.

"And nutriflakes." He said, walking back to the kitchen counter and laying out plates and bowls. "Come."

Dhun hauled herself onto the dining slab opposite the kitchen counter, sitting comfortably on it as Pappa dumped a beaten fried egg onto her plate.

Dhun took a bite of her omelette and said, "A pandemic is a big disease?"

"Yes, a pandemic is a widespread disease. COVID-19 was a pandemic, that came in 2020. Dadu was fifteen years old then. TRIC-1 came when I was eight." He informed.

"So, people died?" she asked.

"Lots." Pappa nodded.

Just then, there was the quack of a duck, and the Big Screen turned green on the edges with two animated running showers. "Our baths are ready. You done?"

Dhun nodded, still chewing, and handed her plate to pappa who said, "You know there was a time when the only way to keep your food warm on the plate was to eat it while it was still warm."

"Yes, and you had to mix hot and cold water to take a bath, and the food would burn if it was left for too long on the stove; there were no auto-temp regulators in anything." She said, rolling her eyes.

Pappa burst out laughing, "Yes, absolutely. I lived in a cave; did you know that?"

Dhun giggled, "You did not live in a cave! I have seen your pictures. Early men lived in caves. You lived in your home."

With that, pappa scooped her up and lifted her over his head like a cricketer holding his bat after making a century.

"Music!" He shouted.

An old A.R. Rehman song oozed around the house.

Dhun and Pappa stood in front of the mirror in Pappa's bedroom. Dhun stared at Pappa's reflection. As Pappa did the buttons of his shirt, Dhun said,

"Can't you take me with you?" she asked.

"No. Not today." He said.

Dhun hated it when this happened. Pappa told her there was a time when people left kids home every day because they had to go to buildings that housed offices where they 'worked'. This had always sounded ridiculous to Dhun. Robots manufactured things, and people reported from home.

But Pappa had to be gone out to their external workspaces at times. Today was one of those days for Pappa.

She nodded.

"Okay." Pappa smiled. "Now, it's completely okay being alone. If there's anything, just alert me. All the emergency

and alert systems are active. I'll be home in no time. And oh, if something crazy happens, you will then go to Shevi's house and call me. Okay?"

"I know; I've been home alone before," Dhun said.

Pappa got to the door and knelt to hold Dhun in a tight hug and said, "I'll be back in no time."

And it sounded like he needed to hear those words himself more than Dhun.

Pappa faced the apartment door, and it unlocked itself. Pappa put his hand on the handle, pushed it open, stepped out and said, "Bye, baby."

"Bye, pappa." She said

Dhun woke up with a start, laying on the sofa.

The screen in front was bleeping with the picture of a nanowave. Dhun sat up. She felt queasy, and her mouth tasted somewhat salty.

She had kept fish fingers in the nanowave and then sat down to watch Solar Space City. Between the soft sofa cushion and a show, she'd watched a hundred times, sleep must've been hard to fight.

She walked across the living room towards the kitchen. She wanted to eat her snack peacefully.

Dhun was licking the crumbs off her fingers when she heard the faint sound of a balloon popping. She looked around. There it was again, a little louder than the previous one. Dhun looked at the screens. Now the third time, the sound sounded like a blast from close by. It was the impending earthquake alert. Buildings did not crash as they used to before unless the intensity of the quake was severe. Even if it did, people did not lose lives to earthquakes. They had enough time to launch themselves into their atmospheric capsules. But there was something unusual today. The photonic systems were collapsing, and gadgets were powering off.

The lights in Dhun's apartment began to flicker; the main screen flickered too. Immediately, the screen flashed: 'Emergency - System Down.'

One would think preparing for emergencies makes it easier. Well, the fear flooding through Dhun yelling catastrophic possibilities disproved that. All Dhun could think about was getting to the other side of the door.

Dhun tapped the door; it clicked open. She leapt out of the house and shut the door behind her. She bolted towards the vestibules.

"Oww," She rubbed her forehead and realised that the vestibules were dead. It did not sense her presence and open the doors to her. Her perpetually invisible neighbours were nowhere in sight. They perhaps had chosen to stay inside their homes and eject out of their homes in their safety atmospheric capsules if there was a catastrophe.

Dhun was alone, out.

Being alone inside the house didn't feel half as terrifying as it did now – stuck between two worlds.

In her panic, she had forgotten her call band. She could not enter her house that had locked her out. She had no idea what she was doing. Her hands were clammy, and her throat was dry. She hadn't thought about any of

his before she left the house. She was desperate and felt tears coming on.

Dhun had to get to Shevi's place. She could call Pappa from there.

But how did one transit without the vestibules?

She could feel an answer fighting its way to the front of her brain. In a force of recollection, her mind walked her feet to the end of the corridor. She looked around, and at the very end of the corridor, in an isolated corner seven feet away from the last house on the floor, was a.....was a.....a.... passage -- "stairs!" the word slipped itself out of her mouth.

In all the years of living here, Dhun had never actually bothered to use them. Nobody had. They only existed in old buildings. The new ones didn't have staircases. Staircases had become part of old traditions people hadn't forgotten; they just didn't remember to revisit them.

Dhun took the first step and then the second one. It was a weird feeling. By the beginning of the second flight of stairs, she climbed without holding the railing. She hopped on the third flight of stairs. By the last one, Dhun climbed like she'd invented staircases.

The door of Shevi's house was open! Dhun's heart sighed in relief with her lungs gasping for air.

Dhun let herself in immediately and shut the door behind her. She straightened her back. Oh, Shevi's house looked diff...

Dhun's stomach knotted.

Wrong house. Wrong floor.

Dhun leapt towards the door and tapped it, but it remained shut. She hated herself for ever having left the house and for forgetting her call band. She felt stupid.

It was clear that there was no way Dhun was getting the door to open. Dhun turned around. She noticed the house was crammed. Chaotic. Dark. Photographs...hanging in frames. There were boxes stacked upon each other. A clock on the wall... the one with three needles. Dhun had always wanted one of those. The floor was wooden under thick layers of dust. The house smelled odd. The dining table was a mess. Stale food was lying on a plate with a cup, an empty vase, a picture frame stood there too, a scrunched-up towel, and a water bottle.

Just then, something croaked, and Dhun turned to her left. There was a heavy couch in front of her with its twin kept opposite it with a table in between.

There was a groan again, and Dhun's vision focused on the human foot peeking from behind the sofa. She froze. Despite every cell in Dhun's body not wanting to, Dhun made herself walk towards the foot slowly. She looked down at a woman, in a nightgown, beside the window, the weight of her head pulling at the drapes. She seemed to be sleeping. Her hair was dishevelled and white. Her skin was sagging.

Dhun waited for a miracle and then called, "Hello?"

The world remained unchanged.

A little louder, "hello???"

Dhun moved closer to the woman, gripped her shoulder, and shook it.

The woman snorted lightly. Dhun kneeled and shook her shoulder harder. The woman let out a gasp, opened her eyes and blinked. Dhun stood, and the woman subsequently raised both her arms. Dhun blinked, then helped her up. The woman, without letting go of Dhun's right hand, began walking. Dhun walked awkwardly with her. The woman walked as if she was an alien in a human body, learning to use 'human feet'. Dhun wondered if she was hurt. Her nose twitched, she wondered if the woman ever bathed.

"You know me?" the woman spoke.

Dhun blinked.

"Uh, I- I.... no. I don't know you," said Dhun. "I live on floor fifteen, you see, and the system shut down, and I..." she choked.

Dhun cleared her throat and said, "I got into your house by mistake, you see, your door was open, I thought I was in my friend's house, but I just..."

The woman cut her off with a sad smile... "Never mind, it has been ages since anyone visited me." The old woman began.

"You know I had lots of friends once. We used to be together all the time – then people died, so many – they said," the woman sniffed her sobs, "they said we should be far because of pandemics, and people stopped meeting. Having dinner together. Everything. I feel it will be back like normal, but no – people forget."

Dhun felt like she was stuck between worlds again.

"And forgetting is normal now. Machines remember everything."

The woman broke down, crying like a kid. "I hug photos. I hug my husband's shirt after he died; I am so lonely, I cry and sleep." Now the woman was wailing, "My son watches me through the machines; he thinks I was dead. I act dead because I know he will only remember then. He comes and tells I have the disease. They are coming to me, take me."

The woman fell to the ground as if it was pulling her.

Dhun had no idea what to do. Or say. Or why she was missing Mumma so much suddenly.

Getting her water seemed like a good idea. Dhun made her way to the kitchen counter. She poured water from a bottle kept on the slab into a glass which spilt on the counter as a voice yelled after a thud, "Door disengaged."

The woman sat on her knees and shrieked, "NO!!!!!!"

A group of five people stepped into the house. They wore masks and gloves. They held the woman by her arms, on either side as she cried out. They stuck a white patch on her arm, and after a minute, the woman became dizzy. They put her on a wheelchair and rolled it out of the house.

"Hu-what?" Dhun looked at one of the paramedics who had come in.

"I said you need to come with us to the hospital."

"I am not her relative. I came here by mistake. I have to go, call my dad."

Just then, the power came back.

"No. We need you to get you to the hospital because you may be contagious from the exposure to her," the medic added.

"She wasn't sick!" Dhun paused. "Was she?"

The medic sighed, "We will get in contact with your father now and ask him to come to the hospital."

Pappa crushed Dhun with a hug. She narrated the whole tale lying in the hospital bed.

After a quiet moment, Dhun said, "What happened to that woman?"

Pappa's eyebrows knotted, "It's a new disease. Many people are getting it."

"Madness?" Dhun whispered.

"That's what. Madness isn't contagious. People can be affected if they grow up around sad people. The world used to be very different. How many friends do you have? The ones you would go to if something happened to Mumma and me?"

"Shevi," Dhun said.

"And?"

"Shevi."

"See? Grandpa must've had at least six names like that growing up. I had three. And now, people have nobody. People feel less. People see each other less, much less than they used to seventy years ago."

"So?"

"So, now, because people have got so distanced, my guess is, we are all a snap away from going mad. We are lonely."

Dhun swallowed. "The woman said she hugs pictures."

Pappa smiled weakly.

"So, will I go mad too?"

Pappa coughed up a chuckle and held her hands, "I don't think so. Children get love, hopefully, from parents, and friends. They are resilient to whatever this is."

Dhun said, "The woman I saw, she needs..."

"She needs somebody who will listen to her. Tell her jokes. Hold her hand. Ask her how she is doing. Take her out. Watch sunsets. Get to know her. Sit next to her when she cries. Take care of her when she runs a fever or has a toothache. Someone who can keep her secrets and let her keep theirs. Cook for her. Someone who calls her by her name," Pappa completed.

"Sounds like a lot of work."

Pappa half smiled, "Doesn't it? People used to do this all the time without even thinking. And now we're worn out just thinking about it."

"Can we be like that again?" Dhun asked.

"We have to," Pappa added. "It will take time. We're just a little bit out of practice."

She stared at Pappa. He flicked his eyebrows.

Just then, something soft hit the window. It was dark outside.

"Oh wow, it's raining," Dhun said.

"After so long," Pappa added.

////////////////////////////////////
Ms Shruti M., Hans Raj College, New Delhi



**80 YEARS OF
IMPACT**

**Council of Scientific &
Industrial Research**

The HANSA Two-seat Aircraft for Pilot Training



Hansa NG – two-seater all-composite trainer aircraft

FLIGHT training is imparted by aero clubs, flying schools or commercial operators where an aircraft is used for the purpose of formal flight instructions with an instructor. Every airline and military pilot begins his or her career in a 2 to 4 seat aircraft cockpit.

A PricewaterhouseCoopers (PwC) Report suggests that approximately 50% of the 2 to 6 seat fixed-wing

aircraft in India are being used for flying training purposes. Many of these are imported aircrafts like Cessna 152 and Cessna 172. As per Ministry of Civil Aviation, due to the rapidly growing aviation market, there is a large requirement of pilots in the country, which creates immense opportunities for the small aircraft production industry.



Hansa 3 – two-seater all-composite aircraft

As per the Aero Club of India, most aircrafts with subsidised Flying Training Organizations (FTO's) in India are now old and are increasingly becoming economically non-viable to operate. Therefore, all FTOs are actively looking to replace these aircraft, and HANSA aircraft of CSIR-National Aerospace Laboratories may be a good option.

The small aircraft market in India is predominantly dominated by foreign players where domestic players have no presence. As per the Market Survey conducted in 2017 by the PwC, the demand estimation based on their primary research is an immediate requirement of 70-80 aircraft for flying training in the country.

HANSA-3 Aircraft

CSIR-NAL has designed and developed Hansa-3 aircraft, an all-composite two-seat light trainer aircraft to be used as an *ab-initio* flying training machine for the flying clubs in India. This aircraft was certified in 2000 when flying clubs needed an advanced trainer aircraft of contemporary class. Hansa-3 aircraft was certified by DGCA under FAR-23 via JAR-VLA in February 2000. It has very good flying qualities, in particular, a docile low-speed behaviour, which makes it ideal for flying training.

Hansa-3 aircraft airframe was developed using the composite technology of 2000 by adopting hand layup, with vacuum bag moulding technique and rivet-less construction. Being completely made of fibreglass and carbon composite materials has inherent advantages like corrosion resistance, damage tolerance, and reparability.

Notable special features of Hansa are a neat cockpit with good visibility, dual control with excellent control harmony (mandatory for trainer aircraft), rugged, operationally cost-effective and easy to maintain; extensively tested for certification compliance including lightning protection; day-night VFR flying capability and turbo-charged engine with constant speed propeller making it easy to operate even from runways at elevated altitudes and hot day conditions.

CSIR-NAL has built 14 production version aircrafts from 2001 to 2010, out of which 11 were delivered to DGCA, one aircraft to IIT-Kanpur and two aircrafts are with CSIR-NAL. The cumulative hours logged by all Hansa-3 aircrafts is about 4000 hours. All the pilots who have flown Hansa-3 aircraft have similar opinions about its excellent flying

characteristics. The aerodynamics, power and controls harmony make flying very comfortable.

HANSA-New Generation Aircraft

During the user interactions, the flying community suggested significant modifications to Hansa-3 aircraft to make it more useful as a trainer aircraft. The modifications included requirements of flying clubs for obtaining PPL (Personal Pilot License) & CPL (Commercial Pilot License) for their learners.

The major modifications proposed were changing analogue instruments to digital state-of-the-art fully glass cockpit display system, reducing the pilot load by changing the mechanically operated flaps to electrical operations, ergonomically designed doors for better ingress and egress, increasing the fuel capacity for higher range and endurance, bubble canopy for an excellent aerial view, and easy to fly with good handling quality and low operations and maintenance cost.

With the above modifications to Hansa, the programme was launched in the latter half of 2018, and the Hansa-NG was rolled out on 31st March 2021. CSIR-NAL received the Letter of Intent (LoI) for about 65 aircrafts from 7 flying clubs/flight training school. An MoU was signed between CSIR-NAL & Indira Gandhi Rashtriya Uran Academy (IGRUA) on 31st March 2021 for Hansa-NG to be the possible launch customer.

The availability of Hansa-NG will boost pilot training with indigenous aircraft. The defence sector can also use Hansa-NG for cadet training and coastal surveillance, furthering the development of a wide variety of small and medium scale private entrepreneurs in producing airworthy components. Further, it will help create an opportunity to give on-the-job training for ITI & Diploma holders in aircraft building and AME training disciplines. Hansa NG would be an affordable and appreciable trainer aircraft for the young generation of pilots.

////////////////////////////////////
R. Venkatesh
 Head, Business Development
 CSIR-National Aerospace Laboratories

(Adapted from the CSIR Blog: <https://www.csir.res.in/blog-csir/success-stories>)



**80 YEARS OF
IMPACT**

**Council of Scientific &
Industrial Research**

Bharatiya Nirdeshak Dravya (BND) or Indian Reference Material: Ensuring reliability, comparability and quality



THE technological leadership of any economy strongly depends on the capability of accurate and precise measurement systems. The confidence in the accuracy and reliability of the measurements lies in the framework where results are linked to respective SI units. Certified reference materials play a crucial role in establishing the SI traceability to the various measurements.

To establish a uniform measurement system, India being the member of Bureau International des Poids et Mesures, commonly known as the International Bureau of Weights and Measures (BIPM) & the APMP, is maintaining standards at par with international standards. CSIR-National Physical Laboratory (CSIR-NPL), New Delhi, being the national measurement institute of India has recently adopted

an internationally accepted modality to produce certified reference materials in association with various reference material producers to strengthen the quality infrastructure. CSIR-NPL has got Bharatiya Nirdeshak Dravya (BND®) as a trademark [TM No.-3669341] for Indian reference materials.

Bharatiya Nirdeshak Dravya is the trademark of Certified Reference Material (CRM) produced by CSIR-NPL in association with Reference Material Producers (RMPs). BNDs are primary standards that ensure reliability and comparability of the measurements as a benchmark for the quality assurance achieved through international networking. Networking between the NMIs through bilateral cooperation, participation with international bodies/organisation establishes wide-ranging recognition of BND in India.

The comparable measurements, i.e. 'once measured or tested, globally accepted' are bound to uplift the quality life of consumers and enhance the socio-economic fabric of the society through unhindered trade. The global analytical standards market of CRM is projected to reach USD 1.73 billion by 2022 from 1.27 billion in 2017, at a compound annual





growth rate (CAGR) of 6.3%. The factors driving the growth of this market depend on stringent regulations over pharmaceutical industry, rising public concern related to optimal food safety and quality, increasing public-private investments in various

researches and growing use of analytical techniques.

The importance of BNDs can be realized by the fact that the US food and drug regulator alone has (year 2000) rejected more than 2,100 import batches of 'made in India' products across food, personal care and health supplement categories, including those made by leading companies. Apart from that EU, Gulf countries, etc. have rejected many supplied recently as well as in the past.

The BNDs produced by CSIR-NPL in different sectors are uploaded in the international COMAR database, i.e. COde d'Indexation des Matériaux de Reference (COMAR), for its global visibility. To enhance the impact of reference materials in the global economy, the Bureau of Indian Standards (BIS) has recently established a national mirror committee on reference materials which is a part of ISO-REMCO (Committee on reference materials). CSIR-NPL has developed several BNDs in association with RMPs. Some of the main successes are as follows:

- **Petroleum Products (BNDs):** CSIR-NPL has successfully launched >28 petroleum based BNDs in association with Hindustan Petroleum Corporation Limited (HPCL) & Bharat Petroleum Corporation Limited (BPCL). Traceability for all vital parameters of petroleum products testing and certification comprising of 12 physical properties, 3 physico-chemical properties and 13 chemical properties including BND for sulphur content measurement at lower concentrations which will be of immense use for BS VI fuels. This unique initiative will be a milestone in ensuring quality assurance of petroleum products in our country.
- **Building Materials BND:** Increasing industrialisation demands high-quality construction materials. In order to improve the quality of the construction, reference standards of building materials are required. For this it may be required to have a large number of reference standard materials like ordinary portland cement (OPC), white cement, cement composites, concrete, steel-reinforced concrete, polyurethane foam, fly ash bricks, portland pozzolana cement, etc. NCCBM is exporting cement BND to countries like France, Austria, Oman, Nepal, Bangladesh, Egypt and UAE.
- **Polystyrene Film for Spectroscopic Standard:** Fourier Transform Infrared (FTIR) spectrophotometer is a powerful characterisation technique that reveals various fundamental facets of materials in many areas such as chemical, analytical, pharmaceutical and biomedical

industries, etc. The reference materials can be used to qualify mid-IR-FTIR spectrophotometer for wavelength accuracy. Calibration, testing laboratories, private sector and FTIR making companies are the users of the reference material. Development of IR reference standard in India will save lot of foreign exchange.

- **Graphitized Petroleum Coke BND:** India imports huge amount of carbon raisers from Japan, China, Korea, etc. The cost of the carbon raiser in turn depends upon the purity, i.e., high fixed carbon content and minimum impurities. The percentage of sulphur for this product is specially monitored as the customers of this product require a minimal level of sulphur. The concentration of these impurities is being routinely analysed by testing laboratories. However, reliable analytical results are required for compliance with international regulations in almost all areas of analysis. The main purpose of the development of this GPC standard is to provide a reference standard to the Indian industries to evaluate the carbon additive for its quality control and in the evaluation of techniques used in the analysis of graphite/carbon and materials of a similar matrix. CRM/BND of graphitized petroleum coke has been developed to ascertain the quality of carbon additive and in the evaluation of techniques used in the analysis of graphite/carbon and materials of a similar matrix.
- **Gold BND 4201:** India is the second-largest consumer utilizing approximately 849 metric tons of gold. Therefore, its purity standardization (Ag, Pt, Pd, Rh, Ir, Ru, Os and Cd) is urgently required for consumer satisfaction. CSIR-NPL has signed MoU with Govt. Mint, Mumbai and Jalna's and Company, New Delhi, for the production of gold standard. In 2017, India's first home-grown high purity gold reference standard BND-4201 was launched at the India Government Mint (IGM) in collaboration with NPL.



- **BNDs Related to Gas Mixture:** Gas Metrology plays a crucial role in the field of global atmospheric monitoring of Green House Gases (GHGs), National Ambient Air Quality Standards (NAAQS) parameters and vehicular emissions as well. CSIR-NPL maintains the primary Reference Gas Mixtures (PRGMs) and conducts Proficiency Testing (PT) in this field. The laboratory has established facilities for the gravimetric preparation of PRGMs, their analytical validation and impurity analyses. This will help in developing indigenous sensors suitable for Indian climatic conditions.

//////////
Dr Nahar Singh
 Head, BND Division CSIR-NPL

(Adapted from the CSIR Blog: <https://www.csir.res.in/blog-csir/success-stories>)

TEST YOUR KNOWLEDGE

The Economically Useful Plants

Pooja Gupta

1. A plant which is the richest source of proteins amongst the legumes, also known as 'wonder bean' owing to its numerous wonderful uses.
 - (a) Kidney bean
 - (b) Cluster bean
 - (c) Soya bean
 - (d) Chickpea
2. A spice known as the 'King of Spices', also termed 'black gold of India'.
 - (a) Saffron
 - (b) Clove
 - (c) Cardamom
 - (d) Black Pepper
3. One of the strongest structural fibres that is used for making tea bags.
 - (a) Manila Hemp
 - (b) Jute
 - (c) Sunn Hemp
 - (d) Cotton
4. The source of the 'quills of commerce' is.....
 - (a) Turmeric
 - (b) Cinnamon
 - (c) Ginger
 - (d) Nutmeg
5. The leaves used for wrapping tobacco in a 'bidi' are.....
 - (a) Tea leaves
 - (b) Tendu leaves
 - (c) Curry leaves
 - (d) Basil leaves
6. The drug from this plant is used as a myocardial stimulant and is used in the treatment of circulatory disorders
 - (a) Foxglove
 - (b) Rauwolfia
 - (c) Poppy
 - (d) Belladonna
7. The plant is known as the 'Green Gold' of India because of its numerous economic uses and the dependency of a large number of rural people on it to earn their livelihood.
 - (a) Sal
 - (b) Pine
 - (c) Bamboo
 - (d) Teak
8. An important source of essential oil, which is used in mosquito and vermin repellents and its vapours give relief cough in chronic bronchitis and asthma, often planted to reclaim swamps.
 - (a) Sandalwood tree
 - (b) Citrus tree
 - (c) Cedarwood tree
 - (d) Blue Gum tree
9. A pseudocereal which is a good source of high-quality proteins besides being high in carbohydrate content.
 - (a) Mickrice
 - (b) Quimaize
 - (c) Buckwheat
 - (d) Welot
10. Fondly called 'The tree of heaven' – Kalpavriksha – an important tropical plant, it provides all the necessities of life. The dried kernel of the plant is

of prime importance though all parts of the plant are useful. In India, Kerala contributes to nearly half of its total production.

- (a) Olive tree
- (b) Coconut tree
- (c) Ashoka tree
- (d) Arjuna tree

11. Tea is one of the most popular non-alcoholic beverages in the world. The alkaloid responsible for the stimulating and refreshing characteristics of tea is.....

- (a) Tannin
- (b) Theol
- (c) Theine
- (d) Tannic acid

12. Vetiver (Khas-Khas) oil, obtained from the Vetiver plant, is extensively used in perfumery and medicine. The primary oil yielding part of the plant is

- (a) Stem
- (b) Roots
- (c) Leaves
- (d) Flowers

13. A plant source of oil that is used in histology as a clearing agent, also as an ingredient of toothpastes and mouthwashes and is used for relieving toothache.

- (a) Clove
- (b) Cumin
- (c) Mustard
- (d) Sesame

14. The coarse fibres obtained from this plant are employed in the manufacture of cigarette paper.

- (a) Jute
- (b) Hemp
- (c) Flax
- (d) Kapok

15. An important insecticide of plant origin that leaves no harmful residue and is biodegradable,

used for pest control, to protect stored grains and in mosquito repellent creams and ointments.

- (a) DDT (dichloro-diphenyl-trichloroethane)
- (b) 2, 4-D (2, 4-dichloro phenoxy acetic acid)
- (c) Dalapon
- (d) Pyrethrum

16. Which of the following is not a citrus fruit?

- (a) Grapefruit
- (b) Mandarin
- (c) Kinnow
- (d) Raspberry

17. Very nutritious seeds which are an excellent source of healthy omega-3 fatty acids, dietary fibres, minerals and proteins (especially tryptophan) and that are free from cholesterol and gluten, also prevent blood sugar spikes are.....

- (a) Watermelon seeds
- (b) Chia seeds
- (c) Barley
- (d) Sunflower seeds

18. Molasses, used for making alcoholic drinks such as rum and several chemicals such as vinegar, industrial alcohol, lactic acid, lactic acid, monosodium glutamate, etc. is obtained as an important by-product during the processing of

- (a) Vegetable dyes
- (b) Tea
- (c) Sugar
- (d) Rubber

Answers

1.c	2.d	3.a	4.b	5.b	6.a	7.c	8.d
9.c	10.b	11.c	12.b	13.a	14.c	15.d	16.d
17.b	18.c						

Contributed by Dr Pooja Gupta, Assistant Professor in Botany, Ramjas College, University of Delhi, Delhi-110007.
Email: poojadubot@gmail.com

NATIONAL TECHNOLOGY DAY SPECIAL QUIZ



Image credit: pixabay.com

1. Name the organisation that has developed Monolithic Microwave Integrated Circuits (MMICs).
 - a) ISRO
 - b) DRDO
 - c) CSIR
 - d) DST
2. Who is the Programme Director and Chief Designer of 'Tejas' indigenously built light combat aircraft of India?
 - a) Kota Harinarayana
 - b) Shanti Swaroop Bhatnagar
 - c) C.N.R. Rao
 - d) Jagdish Shukla
3. The supercomputer Flosolver of India was developed and designed by
 - a) CSIR-NAL
 - b) BARC
 - c) DRDO
 - d) CSIR-NPL
4. Which organisation completes 80 years of service to the nation in 2022?
 - a) ICMR
 - b) ICAR
 - c) CSIR
 - d) DRDO



5. Who established the Indian Atomic Energy Commission and when?

- a) Lal Bahadur Shastri, 12 August 1949
- b) Sardar Vallabhbhai Patel, 14 August 1949
- c) Lal Bahadur Shastri, 13 August 1950
- d) Jawaharlal Nehru, 10 August 1948

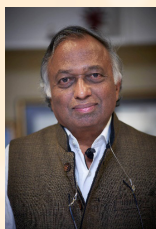
6. Which Indian scientist is popularly known as the missile man of India?

- a) Meghnad Saha
- b) Vikram Sarabhai
- c) A.P.J. Abdul Kalam
- d) C.V. Raman



7. Who is known as the architect of PARAM series supercomputers?

- a) Vijay P Bhatkar
- b) PC Ray
- c) M.S. Swaminathan
- d) Venkatraman Ramakrishnan



8. Indian Institute of Science (IISc), Bengaluru, has installed and commissioned the supercomputer _____.

- a) Param Yuva
- b) Param Siddhi
- c) Param Pravega
- d) Param Shakti

9. When is National Technology Day celebrated?

- a) 9 May
- b) 24 May
- c) 10 May
- d) 11 May

10. India's maiden space mission _____ developed by ISRO will be launched in the year _____.

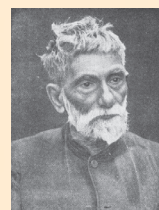
- a) Gaganyaan, 2023
- b) Gaganyaan, 2025
- c) Chandrayaan, 2022
- d) Mangalyaan, 2023

11. Which Indian Institute has identified Next-generation probiotic bacterium *Lactobacillus plantarum* JBC5?

- a) Indian Institute of Technology (IIT), Guwahati
- b) Institute of Advanced Study in Science and Technology (IASST), Guwahati
- c) Indian Institute of Technology (IIT), Kharagpur
- d) Indian Institute of Science, Bengaluru

12. Among the following, which Indian scientist is known as the "Father of Indian Chemistry"?

- a) M.S. Swaminathan
- b) Meghnad Saha
- c) Har Gobind Singh Khorana
- d) Prafulla Chandra Ray



13. Which Indian origin computer scientist had significant contributions to the growth of the AI system and was the winner of the A.M. Turing Award in 1994?

- a) Sankar Kumar Pal
- b) Balaraman Ravindran
- c) Raj Reddy
- d) Pushpak Bhattacharyya



14. Name the Indian physicist associated with the development of India's Atomic Bomb?

- a) C.V. Raman
- b) Satyendranath Bose
- c) Raja Ramanna
- d) A.P.J. Abdul Kalam



15. Which organisation developed Oxygen Enrichment Technology for the treatment of COVID patients?

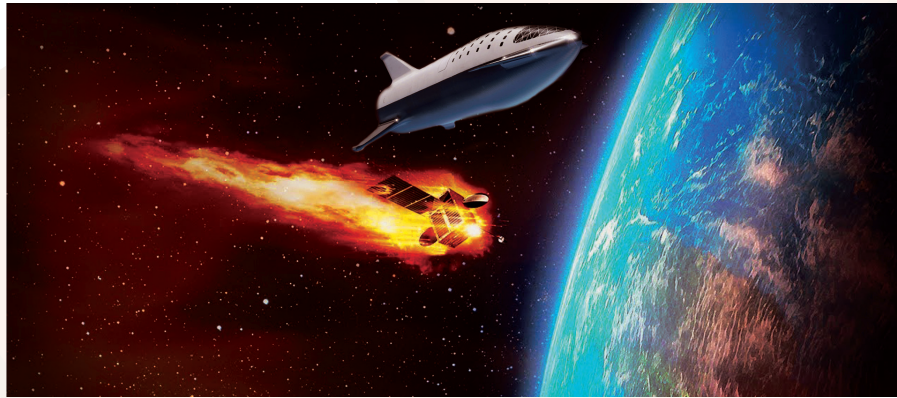
- a) CSIR-NEERI
- b) CSIR-CEERI
- c) CSIR-NCL
- d) CSIR-CMERI

Answers

1.b 2.a 3.a 4.c 5.d 6.c 7.a 8.c
9.d 10.a 11.b 12.d 13.c 14.c 15.d



Did Astronauts Hear the Explosion?



A spacecraft with a few astronauts has left the earth towards Mars at hypersonic speed. During the flight in space, a meteor hit the nearby space satellite and a big explosion took place. The accident happened when the space satellite was just at 50 km distance from the spacecraft. Will the explosion be heard in the spacecraft??

Find the Hospital Equipments

A	N	T	H	O	L	G	E	S	T	H	O	R	E	V	R
B	U	N	D	E	L	Y	S	I	S	R	A	S	I	E	N
S	L	A	E	S	I	W	N	A	R	B	D	T	T	N	S
T	T	B	T	H	E	R	M	O	M	E	T	E	R	T	U
R	R	V	R	T	L	D	F	D	R	B	M	R	E	I	W
A	A	T	U	E	A	G	B	H	S	O	R	I	S	L	Y
V	S	H	M	S	R	M	D	J	N	N	W	L	T	A	H
T	O	J	E	Y	E	I	E	A	I	X	E	I	O	T	S
R	U	S	A	R	S	Y	M	O	U	R	T	Z	F	O	U
I	N	R	N	I	E	O	H	L	Y	A	R	E	T	R	E
D	D	J	T	N	M	R	G	N	W	Y	A	R	H	I	Y
E	G	E	A	G	T	E	W	T	R	S	E	T	E	G	R
S	K	K	Y	E	R	W	D	U	G	T	F	I	W	H	H
Y	F	H	L	T	S	T	E	T	H	O	S	C	O	P	E
E	P	D	I	H	E	Y	D	E	N	R	X	G	T	T	C
S	T	R	E	T	C	H	E	R	M	U	C	R	H	E	G

Match Inventions and Inventors

Invention	Inventors
Dynamite	James Russell
Reflecting Telescope	W.B.Shockley, John Bardeen and W.H.Brattain
Refracting Telescope	George Eastman
Compact Disc	Dennis Gabor
Flexible Film Roll Camera	Wilhelm Roentgen
Google Search Engine	Hans Lippershey
Holography	Alfred Nobel
Transistor	Isaac Newton
X-Rays	Sergey Brin and Larry Page

SOLUTIONS TO THE PUZZLES PUBLISHED IN APRIL 2022

Have a Biscuit!!!

Every girl had 12 biscuits at the beginning and gave 1 biscuit to each boy. Every boy had 36 biscuits at the beginning and shared 3 biscuits with each girl. After equal distribution, every boy or girl had 18 biscuits.

Match the Hormones with their Functions

1→c, 2→d, 3→a, 4→b, 5→g, 6→j, 7→e, 8→i, 9→h, 10→f

Unscramble the Scramble

CARBOHYDRASE

LIPASE

PROTEASE

MALTASE

AMYLASE

TRYPSIN

LACTASE

HELICASE

SOLUTION TO THE CROSSWORD PUBLISHED IN APRIL 2022 ISSUE

Amino Acids

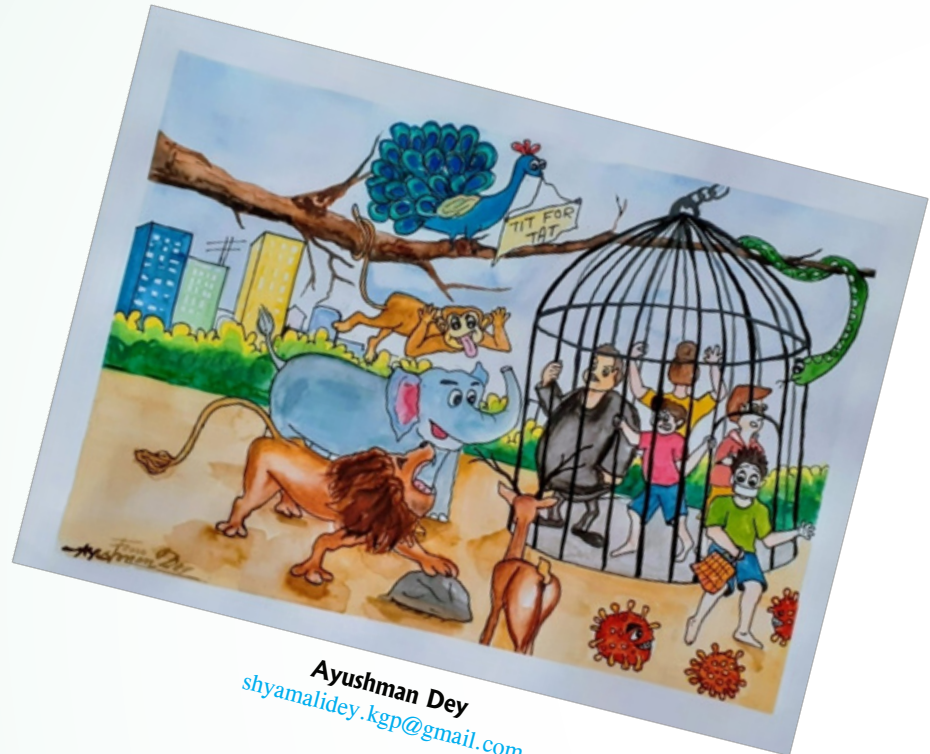
G	L	Y	C	I	N	E			² V	A	L	I	N	E		³ S
L																E
U					⁴ T	R	Y	P	⁵ T	O	P	H	A	N		R
T				⁶ H					Y							I
⁷ A	L	A	N	I	N	E			R							N
M				S			⁸ P	R	O	L	I	N	E			E
I				T		⁹ L			S					¹⁰ M		
N				I		Y			I			¹¹ C		E		¹² I
E		¹³ L		D		S			N			Y		T		S
		E		I		I			E			S		H		O
		U		N		N						T		I		L
		C		E		E						E		O		E
		I										I		N		U
		N										N		I		C
¹⁴ P	H	E	N	Y	L	A	L	A	N	I	N	E		N		I
														E		N
¹⁵ T	H	R	E	O	N	I	N	E	¹⁶ A	R	G	I	N	I	N	E

SCIENCE CARTOON COMPETITION

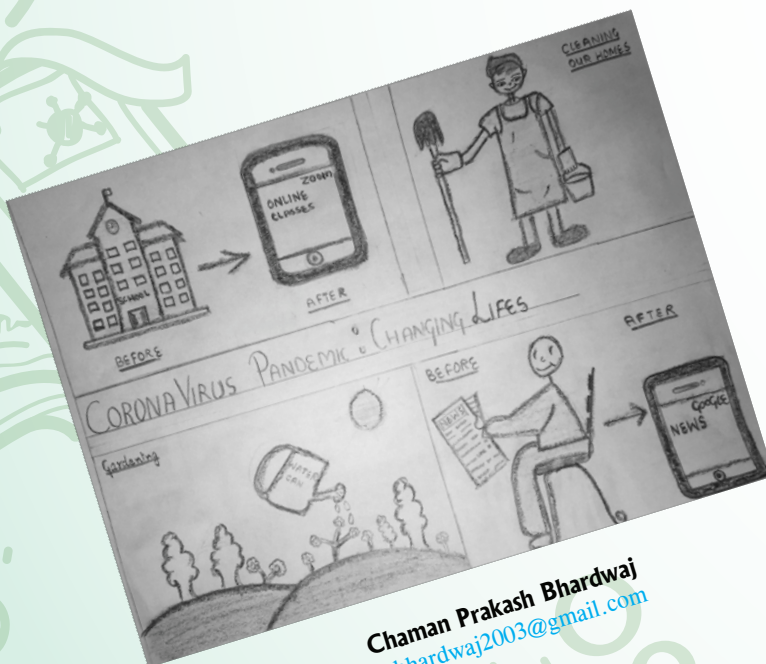
Online Drawing Competition 2020

"ART CARO NA"

Group II (Class IX-XII): Coronavirus Pandemic – Changing Lives".



Ayushman Dey
shyamalidey.kgp@gmail.com



Chaman Prakash Bhardwaj
cpbhardwaj2003@gmail.com

