Connect

with the Indian Institute of Science

Volume 11 · Issue 2 · June 2024

After Hours
Nightlife on campus

Reel and Reality
Inspirations from sci-fi

Far from Land
Adventures on a ship

ISSN 2454-6232

IN THIS ISSUE

EDITORIAL

Plastics are choking our planet. Is there no hope for getting rid of this insidious material? In this issue of *CONNECT*, we explore the challenges of recycling and replacing plastics, with insights from scientists who are trying to reduce this pervasive problem.

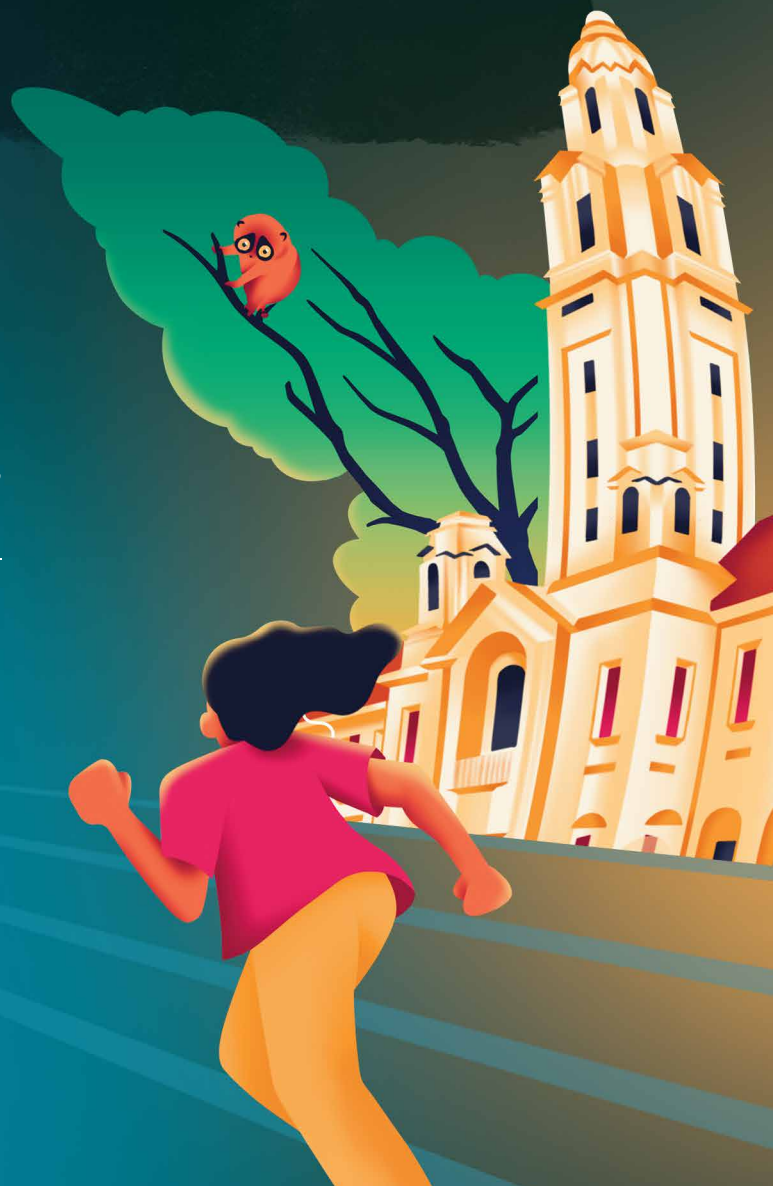
In student stories, two researchers recount once-in-a-lifetime experiences of journeying to deep oceans, while another student describes how the campus comes to life at night.

We also dive into the world of science fiction, a genre that has shaped science and scientists over the years, while students talk about their favourite sci-fi works in our column *CONNECT ASKS*.

This issue also features a candid interview with alumnus Parveen Kaswan about what it takes to be an IFS officer. Ranganayaki, a former draughtswoman, reminisces about her time at IISc.

In other stories, we delve into the fascinating evolution of transmission electron microscopy and the technicians toiling behind the scenes of MBU's X-ray facility. Deputy Registrar Veeranna takes us around campus, giving us a glimpse into a day in his life. We also visited a centre at the Challakere campus that seeks to strengthen local communities by training them in sustainable technologies.

Happy reading!



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Design: Magnetyz
Cover illustration: ZEROKELVIN
Printer: Sri Sudhindra Offset Process

Aboard the icebre

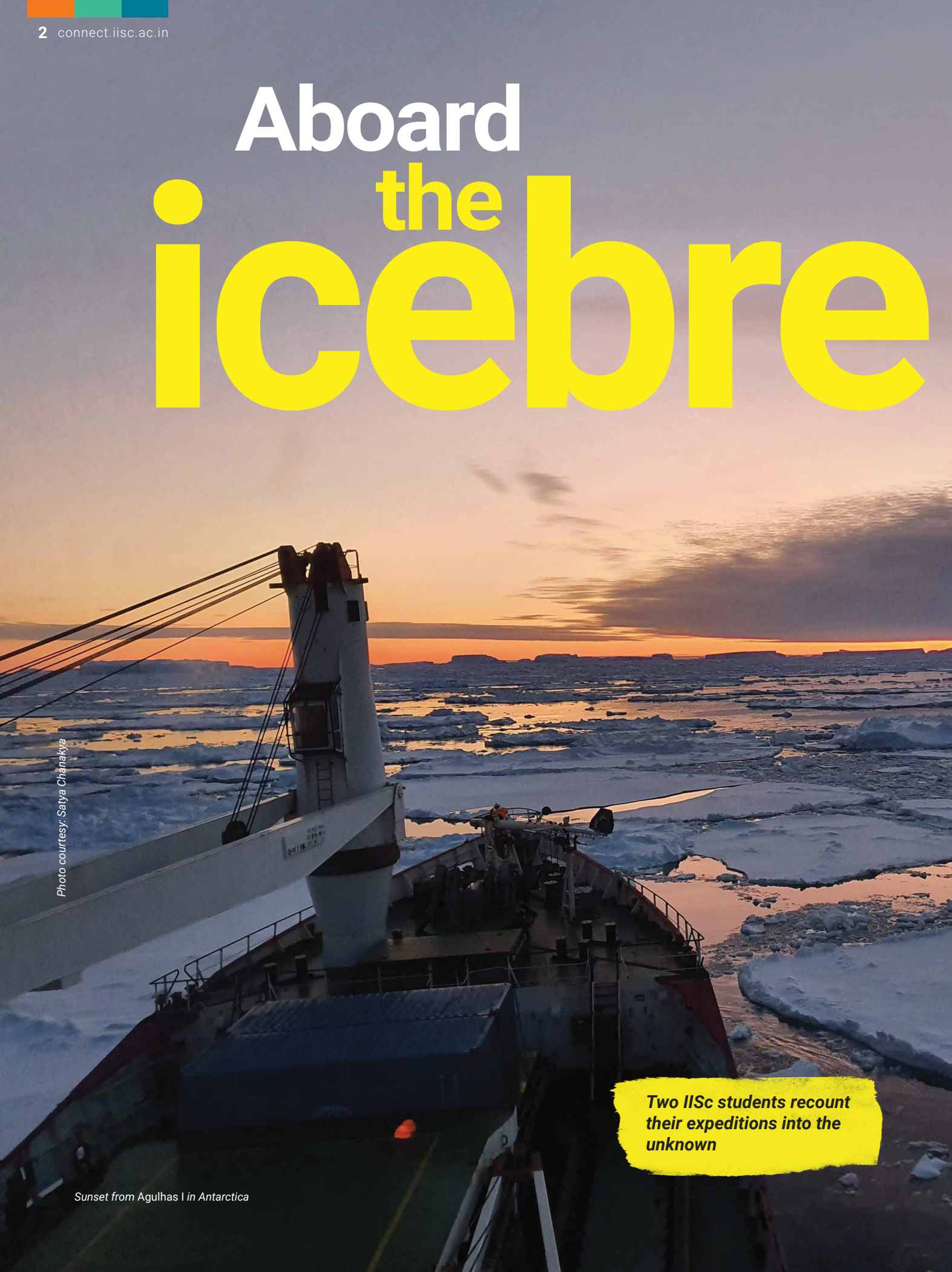


Photo courtesy: Satya Chanakya

Two IISc students recount their expeditions into the unknown

Sunset from Agulhas I *in Antarctica*

aker

- Sankeerthana Avasarala

Satya Chanakya jolted awake when he fell off his bed in the middle of the night. He felt disoriented, wondering if he was dreaming. The room was swaying around him, and he heard a series of announcements through a speaker, asking everyone to remain in their rooms. As he lay on the floor trying to gather his thoughts, it struck him that he was on a ship thousands of kilometres from the nearest landmass, in the middle of the Southern Ocean. A far cry from a typical day as a doctoral researcher.

A PhD student at the Centre for Earth Sciences at IISc, Satya was travelling to the Southern Ocean to collect samples of the ocean bed for his research. Just six months before, in July 2019, Satya and his advisor, Sambuddha Misra, had submitted a research proposal under the Indian Southern Ocean Research Programme. He wanted to study how the Southern Ocean contributed to the end of the last ice age, about 18,000 years ago.

The Southern Ocean, also called the Antarctic Ocean, is one of five ocean basins on the planet, surrounding the continent of Antarctica. It plays an important role in regulating global climate by absorbing heat and CO_2 from the atmosphere and driving global ocean circulation. The part of it that lies between India and Antarctica is considered to be the least explored. "Studying this part is vital because it contains the largest volume of oceanic water in the Southern Ocean without any nearby landmass," says Satya.

The Earth cycles through glaciation and deglaciation, first freezing for tens of thousands of years, melting briefly, and then freezing again. The last deglaciation occurred about 18,000 years ago. This happens when CO_2 levels in the atmosphere increase beyond a certain saturation level; during the last deglaciation, there was an increase of 100 ppm (parts per million) of CO_2 in the atmosphere. Researchers hypothesised that the Southern Ocean was the main contributor to this CO_2 rise, but they needed proof.

> ***As he lay on the floor, it struck him that he was on a ship thousands of kilometres from the nearest landmass, in the middle of the Southern Ocean***

That is what Satya had set off on this journey for. But he had no idea that this would turn out to be an adventure of a lifetime.

To the end of the Earth

On a bright sunny morning in January 2020, Satya and a crew of scientists from different institutes in India boarded the research vessel *Agulhas I* in Mauritius. Named after an ocean current and plateau in the Indian Ocean, *Agulhas I* was an "icebreaker" – a ship designed to cut through 100 km-long ice sheets that are typically encountered enroute to Antarctica.

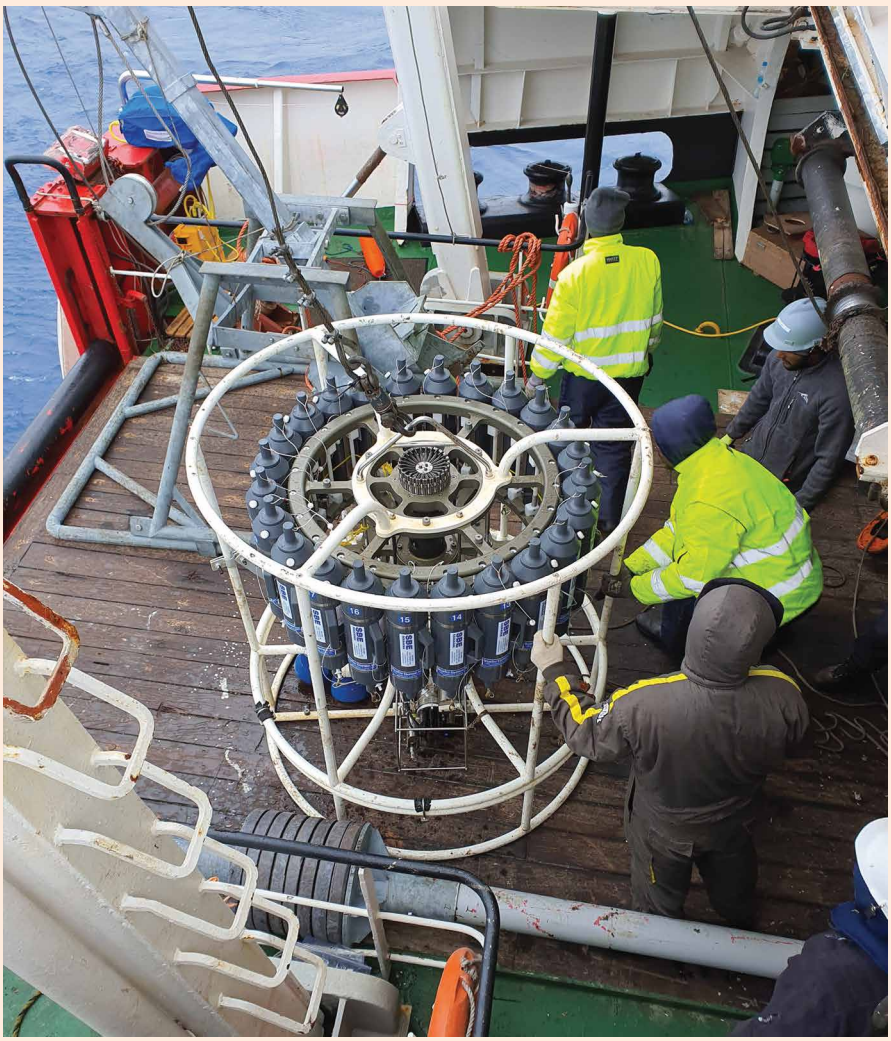
Along the way, the ship anchored at multiple locations mid-ocean, called stations, to collect ocean water and ocean bed sediment samples. The researchers on board were divided into teams, each assigned a station to take control of. As station managers, they worked with the captain and the drilling engineers to deploy the sample collectors and sensors. At each station, gravity and box core collectors would be sent down into the ocean bed, about three kilometres below sea level, to obtain ocean bed sediment, also called 'core samples'.

Once the core samples were extracted, Satya's team would swing into action. Using custom-made tools, they would cut the core into smaller sections and sort them with utmost care.

Satya's goal was to identify trace elements in the core samples, particularly boron and its isotopes. Boron is an established proxy indicator for reconstructing past ocean pH levels, which in turn are influenced by atmospheric CO_2 concentrations.

Since these elements are present in minute quantities in the samples, they need to be dealt with extreme care to prevent contamination from external sources, such as cutting tools. It took about 10 hours to cut each core sample into one-centimetre-thick sections. The work was labour-intensive, and other teams would often pitch in.

Photo courtesy: Satya Chanakya



The crew on board gearing up to deploy sample collectors to obtain ocean floor sediments

After 15 months of meticulous analysis of the samples, Satya found significant changes in the boron isotope concentrations around the time the last deglaciation occurred. They finally had the proof that the Southern Ocean did indeed largely contribute to the increase in CO_2 levels during the last deglaciation cycle.

> ***It took about 10 hours to cut each ocean bed core sample into one-centimetre-thick sections***

"Climate prediction models are trained on past climate data. The better the quantity and the quality of past data, the more reliable the predictions of the model would be. Understanding the effect of high CO_2 levels on the past climate can help foresee their effect on future climate change. COP, IPCC and major climate summits use these model predictions to draft economic policies to tackle climate change," says Satya.

Deep dive into the past

About two years after Satya's successful expedition to the Southern Ocean, Pratyusha Chanda, another student from the Centre of Earth Sciences, set out on an ocean research expedition, this time to the Agulhas Plateau, an oceanic plateau in the south-western Indian Ocean, about 500 km below South Africa. She had applied for a research expedition through the International Ocean Discovery Program (IODP), an international marine research collaboration of about 21 nations, of which India's Ministry of Earth Sciences is a key funding partner.

Through this expedition, Pratyusha was looking to resolve a geological conundrum much farther in the past – how much did the Chicxulub asteroid's impact on Earth 66 million years ago contribute to the global mass extinction event that also killed the dinosaurs. This is known as the Cretaceous-Tertiary (K-T) boundary extinction in which 70-80% of all species on Earth at that time were eliminated.

Photo courtesy: Pratyusha Chanda

Pratyusha with the ocean bed samples in a lab on the JOIDES Resolution

A competing theory claims that an intense volcanic eruption that occurred 66 million years ago in the western Indian Ocean, which covered the atmosphere with toxic gases, was the main reason for the dinosaur extinction. "Scientists now theorise that both these events contributed to the extinction. Part of my work is to estimate the relative contribution of these events," explains Pratyusha.

> ***Pratyusha was looking to resolve a geological conundrum from 66 million years ago***

To understand how much the asteroid impact contributed to the mass extinction, Pratyusha and her team were looking to analyse levels of an element called osmium, which is found in higher amounts in asteroids than on Earth. They wanted to obtain high quality K-T boundary sediments from the Indian Ocean bed and study their osmium isotope signatures. If high amounts of osmium are detected at the K-T boundary, then it would prove that this is due to additional osmium from the asteroid impact.

Pratyusha's expedition set off from Cape Town, South Africa in February 2022, with a crew of researchers from Germany, UK, China, and USA, amongst other nations. After they had settled aboard the *JOIDES Resolution* research vessel, the scientific crew was split into day and night shifts. In this expedition, the ocean bed cores retrieved were deeper than Satya's, about five kilometres below sea level. Once the drilling engineers on deck retrieved the cores, Pratyusha would get to work in the core lab. As a sedimentologist, she would analyse the core in detail – examining its physical features such as colour, grain size, texture; categorising different climatic events of the past through radiocarbon dating, and documenting everything along with photos to build a repository for future explorers.

Multiple expeditions to various oceans had previously failed to obtain the K-T boundary sediment because very few ocean beds worldwide have this sediment well-preserved. The Agulhas Plateau was considered one such exception. Pratyusha and her team successfully retrieved the sediment intact through seismological analysis and careful drilling of the ocean bed.

"Everyone cheered when we got the K-T boundary sediment for the first time," recalls Pratyusha.

Experience of a lifetime

Life on board a ship was drastically different from that on land for both researchers. As they sailed across latitudes and longitudes, days and nights blurred into one another, and they lost sense of time passing. Satya's ship followed the GMT regardless of the conditions outside, to stick to a daily routine.

On their 70-day voyage, Satya and the crew also experienced frequent and intense storms. "I did not know swimming, but it would not have helped anyway," comments Satya.

> ***'We will know not to search for you if you accidentally fall off the ship. We will mourn you'***

The researchers were advised to always take a companion on deck while sailing. The ship was enormous, and if someone were to go missing, people would not even realise it for a few days. They would assume you are elsewhere on the ship. Satya recalls a rather ominous briefing when they boarded the ship: "We will know not to search for you if you accidentally fall off the ship. We will mourn you. If you fall off the ship, it'll be half an hour by the time we can stop the ship. But by then, you'd have been carried far away by the strong currents of the Southern Ocean. We might try, but we will surely not retrieve you alive. You'd be frozen before we even halt the ship to mount a rescue."

The Indian part of the Southern Ocean is tumultuous. Since there is no land mass around it, winds are heavy, and the

Photo courtesy: Satya Chanakya

Satya and the crew experienced frequent and intense storms on their expedition

currents are strong. Although the ocean temperature is -3°C, the strong winds make it feel like -30°C. "One day, during my duty on the deck, the ship tilted, and I got dragged about five metres on the ship floor before I found a hook to hold on to, or else I could have slipped and fallen into the ocean. Another time, the winds were so intense, I could not stand. I had to crawl back under cover," says Satya.

The scientific instruments and equipment on board were locked to tables with nuts and bolts to prevent them from sliding off. The lunch plates would stick to the adhesive mats on the dining room tables. Despite the shaky dining experiences, the cooks managed to make scrumptious cakes, cookies and ice creams on birthdays and special occasions such as Republic Day to feed the ravenous researchers. "The Madras mutton curry was my favourite," says Pratyusha.

But amidst the challenges, there were also moments of wonder that allowed the researchers to experience natural beauty. Satya remembers seeing whales, seals, penguins, and even bioluminescent algae during the expedition, which lit up as the waves hit the ship. Pratyusha also loved the moments of peace on deck to witness the sunset every day. "It became a ritual for us to gather around and see the sunset. The ship would turn off the lights in transit, and we would go to the upper decks at night to soak in the clear skies full of stars."

It is important for researchers to participate in such ocean expeditions themselves, they both emphasise, as it helps them gain experience in handling core samples and know what mistakes to avoid. "As a beginner, we might know what to do with the core samples, but we don't know what *not* to do," says Satya. Mishandling the samples can give spurious results, and these can be avoided if the researcher is involved in the sample collection stage itself. "Your specialisation and presence are necessary as you direct the sample collection and handling in real-time according to the sample requirements for your research," says Pratyusha.

Beyond technical skills, the experience offered other skill development too. For Pratyusha, it was her writing and presentation skills. "Every week, we had to note our observations of the core samples with detailed descriptions and present a progress report," she says.

Satya says that his social skills too vastly improved due to sharing space with all kinds of people. "I learnt to adjust because nothing was under my control – not the food, climate, friends, or even time zones. We lose connection with the outside world; it is like a *Bigg Boss* house. You get to know people well in a short time because you see them at their worst – exhausted, hungry, irritated, scared, sleep-deprived, sad, and homesick – and how they react to these situations."

> ***'The ship would turn off the lights, and we would go to the upper decks at night to soak in the clear skies full of stars'***

When their expeditions ended, Satya and Pratyusha were relieved to set their feet back on stable land safely. But they continue to remember their time at sea with great fondness. Satya says: "There was always something to do on the ship. There was always someone who needed your help. So, if you are willing to help and learn, you never get bored."

Sankeerthana Avasarala is a PhD student at the Department of Materials Engineering, IISc and a science writing intern at the Office of Communications

Photo courtesy: Satya Chanakya

Penguins spotted by the Agulhas I *crew in Antarctica*

Tale of TEM

- Vivek Kumar

Photo: KG Haridasan

A deep dive into the evolution of the microscope that has enabled groundbreaking discoveries

Ambresh M, Senior Facility Technologist, handling the Titan, a Transmission Electron Microscope at CeNSE

In my eighth grade classroom, amidst sunbeams dancing on dusty desks, the creaking sound of the ceiling fan, and the pungent smell of chemicals, my science teacher Deepak Sah's words painted a universe where tiny things held big secrets. We learned about simple and compound light microscopes capable of revealing worlds invisible to the naked eye. "But wait, there's more!" he'd say with a wink. "There are electron microscopes that use electrons instead of light to increase the resolution further." A fascination for these magical machines took root in my mind. But I had many questions. What did resolution mean? Why electrons and not light?

It took me several years to learn some of the answers. I learned that resolution is the smallest gap between two points before they blur together. Our eyes max out at a resolution of around 0.1 mm, roughly the thickness of a fine spiderweb. A trusty light microscope could stretch that to 0.3 micrometres – a thousand times higher resolution – enough to reveal the hidden world within a grain of sand. But even this machine can't catch the dance of atoms – about 3,000 times smaller – which drives almost all material properties, from strength to magnetism to superconductivity.

Zooming into the atomic level isn't just about magnification. In 1879, English mathematician Lord Rayleigh showed that the resolution limit depends directly on the wavelength ("size" or "step") of the light shined on the object and inversely on the microscope's numerical aperture. Like a detective's ability to discern footprints based on boot size, the microscope's capability to resolve fine features was directly tied to the wavelength of light it used. Even the most powerful light microscopes are limited because visible light exists only at long wavelengths, much larger than the size of atoms.

> ***By firing high-energy electrons at an object and tracking their scattering and/or absorption, scientists can map out an object's structure down to atomic arrangements***

In 1925, French physicist Louis de Broglie proposed an audacious idea: Particles like electrons can also behave like a wave, with wavelength inversely proportional to the square root of its energy. If electron beams are given an energy boost, their steps (wavelengths) would shrink, improving resolution drastically, turning these electrons into nimble nanoscale detectives. By firing high-energy electrons at an object and tracking their scattering and/or absorption, scientists can map out an object's structure down to atomic arrangements.

During my second year of Integrated PhD at IISc, I came to learn about different types of electron microscopes. There are Transmission Electron Microscopes (TEMs), which fire electrons at samples to peer at their interior, and Scanning Electron Microscopes (SEMs), which scan surfaces to create 3D images. TEMs generally have higher resolution. However, compared to SEMs, they are typically more complex, expensive, and require specialised sample preparation.

"The origins of electron microscopy can be traced back to groundbreaking work of German physicists Ernst Ruska and Max Knoll in the 1930s when they created the first TEMs," says Pavan Nukala, Assistant Professor in the Centre for Nano Science and Engineering (CeNSE), IISc. "After that, the name of the game has always been to improve the resolution."

Boosting resolution

In the beginning, there were two main strategies for improving resolution – decreasing the wavelength of electrons or increasing the TEM's numerical aperture. Decreasing the wavelength centred on boosting the energy of electrons, starting from 100 KeV TEMs and going up to two-storey-tall TEMs capable of firing electrons at 2,000 KeV. But this proved problematic.

"This brute-force approach posed challenges because materials couldn't

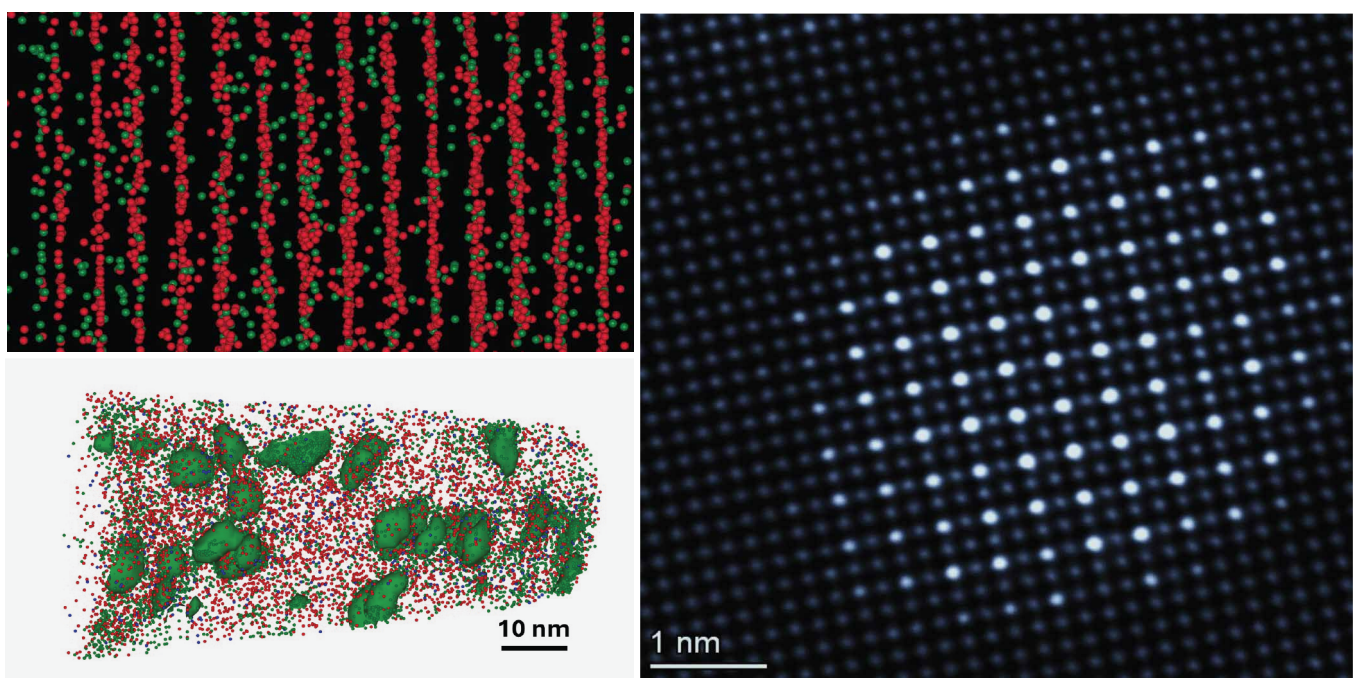


Photo courtesy: Hemanth Kumar, Surendra Kumar Makineni, Rajeev Ranjan

A collage of images showing individual atoms in crystalline alloys taken using Titan Themis 300 kV and Leap 5000 XHR

always withstand these very energetic electrons," explains Pavan. "[Scientists] realised that these electrons could even damage specimens and alter the surface morphology of materials under study."

Soon, scientists shifted their attention to the numerical aperture. Increasing it allowed more electrons to be collected and enabled the use of smaller probes. However, larger apertures introduced imperfections in image quality, like colour fringes, blurs, and distortions.

Subsequent breakthroughs focused on developing aberration correctors. These correctors use complex algorithms and electromagnetic lenses to "undo" lens-induced aberrations in real-time. This correction significantly enhances imaging clarity, precisely manipulating the electron beam to focus more accurately on nanoscale structures and materials, even with low-energy electrons.

But by the 2000s, attempts to correct aberrations plateaued, just like the very high-voltage TEMs.

Finally, researchers decided to focus on improving the detectors – enhancing the signal-to-noise ratio of the obtained data. Modern detectors are quite sensitive and capable of capturing a broad range of electron signals, allowing for better image contrast and detail. Together, these innovations have propelled electron microscopy to unprecedented levels of resolution and clarity.

"These advancements have pushed the boundaries to the extent where resolutions as fine as 20 picometers [one-trillionth of a metre] have been achieved and documented in the Guinness World Records," says Pavan. "It serves as a testament to the remarkable progress made in electron microscopy."

Current efforts in the TEM world are directed towards sample holders, explains Surendra Kumar Makineni, Assistant Professor at the Department of Materials Engineering (MTE). Specialised liquid cell holders allow scientists to watch a chemical reaction like corrosion or oxidation unfold like a live performance in incredible detail. Holders that can strain the sample and provide electric and magnetic biases let scientists see how materials behave under electric or magnetic fields at the atomic scale.

Advancements are also happening in sample preparation. Traditional methods like polishing and ion milling can introduce unwanted artefacts that hinder a clear view. Focused Ion Beam (FIB) techniques are better. But gallium ions, commonly used in FIBs, can still interact with the material, leaving artefacts behind. The latest breakthrough in sample preparation is plasma FIBs utilising xenon sources. Xenon interacts very little with most materials, resulting in samples with significantly less damage and offering a much clearer view of the underlying structures. Instruments like Energy Dispersive X-ray Spectroscopy and Wavelength Dispersive Spectroscopy that work in tandem with TEMs are also allowing scientists to identify elements quickly and efficiently.

Costs and challenges

How much does a TEM cost? This was another question that came to mind when I started using them for my PhD.

"The typical cost of cutting-edge TEM can vary, usually around Rs 15-20 crore, depending on specifications," Pavan answered. "Funding for a TEM can be challenging, especially for individual labs. I wouldn't want to buy a TEM for myself and keep it in my lab just to do my research. It's often managed as a central facility to maximise accessibility, which is the best use of taxpayer's money."

As a trainee, I also realised that operating a TEM is quite challenging compared to other instruments. Pavan points to a common misconception about TEM. Many users, he says, view it as a daunting "black box". There may be some logic to this fear, given the costs involved with what appear to be genuine mistakes. As a result, one needs to deeply understand how it works to be able to operate it safely and to its full potential, which is an activation barrier for people. "However, with advancements in automation, the robustness against human errors is increasing. So, administrators can relax a bit from the erstwhile mentality and create confidence-building measures, as well as an environment where TEMs are democratised and used without fear," adds Pavan.

In a research institute like IISc, maintaining behemoths like TEMs is no small feat. There are constant interactions between the Institute and vendors supplying these machines. Dedicated technicians are the first responders who keep running these instruments smoothly.

About 95% of technical issues – small repairs and replacements – can be resolved locally, Pavan says. However, for the trickier 5%, expertise from abroad might be needed, which can add to the budget. This responsibility falls on faculty members, who juggle research with ensuring these tools keep generating valuable data.

Pavan points to a common misconception about TEM. Many users, he says, view it as a daunting "black box"

One way to offset these extra costs is by charging for facility use. This helps cover maintenance costs and allows the Institute to hire dedicated staff instead of relying on temporary student operators. In the long term, there is a need to create a culture where everyone, from researchers to technicians, contributes to keeping these instruments in top shape, Pavan says.

TEM at IISc

"The microscopy tradition at IISc is the [microscopy] tradition of India," says Kamanio Chattopadhyay, Emeritus Professor and National Science Chair at MTE.

Although the first TEM microscope was built in the late 1930s, it did not become commercially available until 1949. Till then, researchers built their own. "The first microscope in the history of Indian science was built at Calcutta University by NN Das Gupta in 1947-48," recalls Kamanio. One of Das Gupta's close associates, DL Bhattacharya, joined IISc in the early 1950s. It was then that IISc decided to buy the Philips EM100, one of the first commercial TEMs ever built, launched in 1949. It was processed in 1951-1952 and installed on the ground floor of the Department of Metallurgy (later MTE). "I do not know where that microscope went," Kamanio adds. "I tried hard to find it when I came to IISc in 1981 ... it was probably melted down."

In 1978, the Institute procured a Philips EM300, the latest at the time. It was also briefly installed in the Department of

Metallurgy and later moved to the new building of the Materials Research Laboratory (MRL) after it became ready. In 1982, faculty members led by CNR Rao and S Ranganathan secured funds to purchase the JEOL 200CX and asked Kamanio and Subbanna, a scientific officer, to set it up in MRL. "Subbanna's contribution was tremendous," reminisces Kamanio.

> ***In the early 1950s … IISc decided to buy the Philips EM100, one of the first commercial TEMs ever built***

MRL became the Materials Research Centre (MRC) in 1987, and the demand for microscope time increased. "We had some difficulty, at least in metallurgy, because we were doing a lot of work," Kamanio says. In 1990, he and Ranganathan managed to buy the JEOL 2000 FX II, which served well into 2015.

In 2001, M Vijayan, the then Associate Director, asked Kamanio, Chair of MRC at that time, to set up a cutting-edge TEM (the Tecnai F-30 FEI microscope) at the Institute. It was an initiative of IISc with matching funds from the Department of Science and Technology. At that time, faculty members Sanjay Biswas from the Department of Mechanical Engineering and Vikram Jayaram from MTE got a grant for a Focused Ion Beam microscope. The Institute also received funds for an SEM from the Nano Mission. It was suggested that all these microscopes should be kept together, which was supported by Goverdhan Mehta, the then Director. An old residential building was identified near the BSNL telephone exchange and renovated due to the efforts of Kamanio, Subbanna, Vikram and Arup Kumar Raychaudhuri. Called the Institute Nanoscience Initiative (INI), it was inaugurated in 2003. "Unfortunately, Subbanna did not live to see the centre start," Kamanio says.

After INI was inaugurated, two new TEMs arrived, including the high-resolution T20 (Tecnai, FEI) and F30, Surendra recounts. With 200 KV and a thermal emission source, the T20 offered solid performance. The F30, packing a 300 KV punch and a field emission source, boasted even higher resolution due to its more focused electron beam. Notably, it could also switch to a scanning mode.

N Ravishankar, Professor at MRC, then secured funding through the Swarna Jayanti Foundation for another TEM – the ST20 (Tecnai, FEI) – and decided to place it at INI instead of his own lab. It offered functionalities similar to the T20. However, none of the microscopes had an aberration corrector. The T20 wasn't destined for a very long life. Lens issues forced its decommissioning within a few years.

In 2010, the INI was renamed as the Advanced Facility for Microscopy and Microanalysis (AFMM) with the mandate to develop an ecosystem to facilitate the study of the structure and chemistry of materials at the atomic scale. Its goal is to develop manpower and capacities to carry out cutting-edge research by continuous development and training.

In the first decade of this century, the microscope world saw rapid developments, including aberration-corrected lenses and beam monochromators. This led to the arrival of a new champion – the Titan (300 kV Themis, FEI), a very expensive tool. Realising the importance and associated funding difficulties, P Balaram, the then Director, decided to fund the basic microscope from internal resources. Further funding from DRDO, due to the efforts of faculty member Dipankar Banerjee, upgraded its abilities with a monochromator – to ensure that only one electron wavelength interacts with the sample for razor-sharp resolution – and a probe corrector – to account for aberration, eliminating any beam imperfections for atomic-level imaging. Additionally, its electron energy loss

Images courtesy: Kamanio Chattopadhyay

Clockwise from top left: Philips EM300 (1978), JEOL 200 CX (1982), JEOL 2000 FX (1990) and Tecnai F30 (2005)

spectroscopy (EELS) capability allowed precise detection of lighter elements. Integrated differential phase contrast (IDPC) imaging has recently been installed in the Titan, further enhancing light element mapping. A super Energy Dispersive X-ray Spectroscope (EDS) now rounds out its impressive arsenal, making it a dream tool for mapping individual atomic column compositions. Additionally, for atomic scale compositional analysis and 3D tomography, a state-of-the-art atom probe (LEAP 5000 XHR) was also procured in 2017 that boosted the AFMM capabilities in material characterisation.

CeNSE also recently acquired a Titan microscope, but without the aberration corrector, placing it closer to the AFMM's F-30 in capabilities. However, it is a great tool to image nanoparticles. Today, these microscopes hum with activity, serving both IISc researchers and external partners.

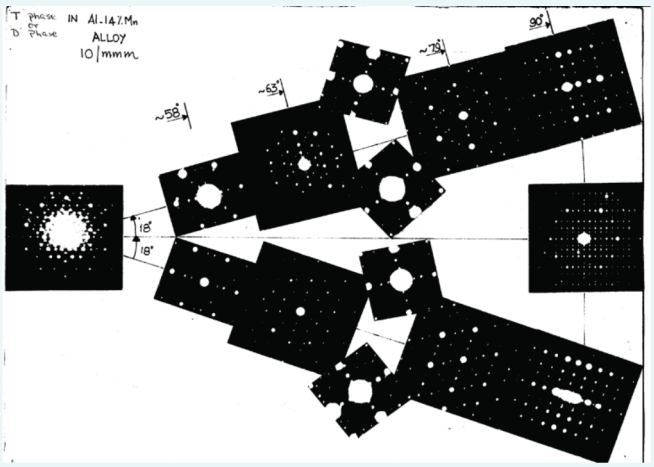
Enabling breakthroughs

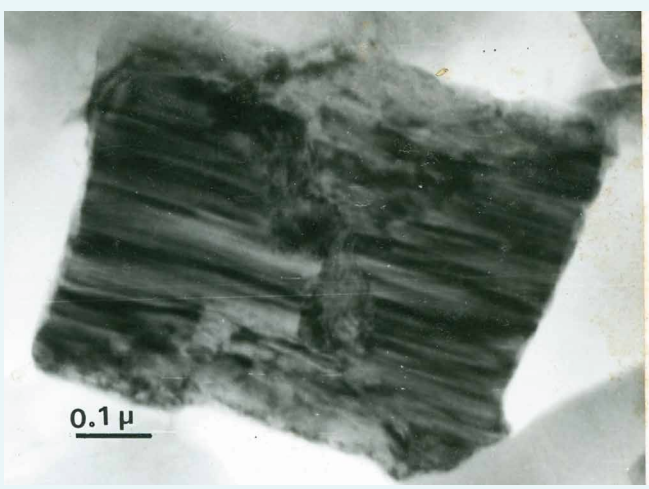
For decades, these microscopes have helped scientists at IISc make groundbreaking discoveries. For example, quasicrystals, which led to a 2011 Nobel Prize in Chemistry, were discovered in 1984 by Dan Schechtman at the National Bureau of Standards, Washington. "Within three months of that, we discovered decagonal quasicrystals, only because of the Philips 300," Kamanio says. Other contributions include the discovery of superheating during phase transformation in the 1990s and work on nanowires by Ravishankar in the early 2000s, he adds.

> ***For decades, these microscopes have helped scientists at IISc make groundbreaking discoveries***

Surendra recalls another instance. In 2010, when he was a PhD student under Kamanio, he stumbled across a research paper describing a promising cobalt-tungsten superalloy. It offered impressive strength and heat resistance, surpassing traditional nickel-based alloys used in jet turbines. However, its high tungsten content made it heavy and impractical for real-world applications.

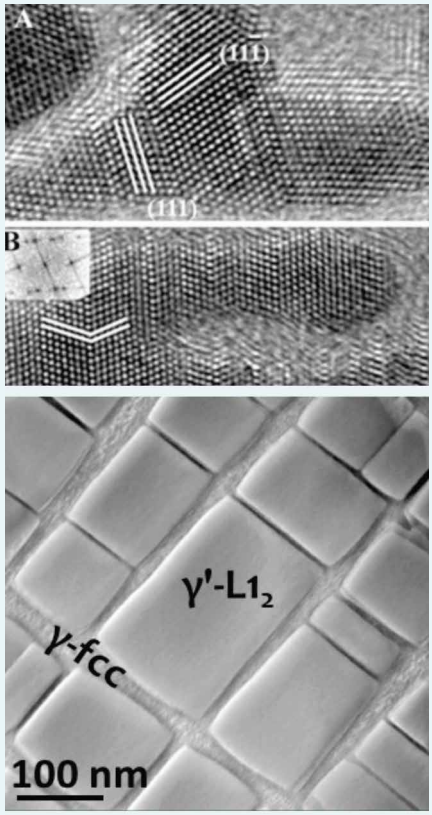
Surendra, along with Nithin Baler, an MTech student, started scouring the periodic table for alternatives. Molybdenum emerged as a candidate, but not on its own. The breakthrough came when they added a small amount of niobium to it (cobalt-aluminium-molybdenum-niobium) – the microstructure stabilised, significantly reducing weight without sacrificing performance.





A series of diffraction patterns recorded in the Philips EM300 of a decagonal quasicrystal

Images courtesy: Kamanio Chattopadhyay



Top: High-resolution atomic-scale imaging of Au nanowires. Bottom: Block-shaped coherent precipitates (γ') in a Co-Al-Mo-Nb superalloy

Images courtesy: N Ravishankar, Surendra Kumar Makineni

One late night, peering at the new material through the F30 TEM at AFMM, they saw that it showed the exact cubic structure as the original tungsten-based alloy, validating their intuition and theoretical predictions. Excited, Surendra called Kamanio at 1 am and informed him of the discovery. "Nobody thought that such an alloy could exist," Kamanio recalls. The very next day, they started writing the manuscript. After some difficulties, the paper was finally published in 2015. The discovery sparked significant interest in the scientific community and even secured a research grant of Rs 5 crore from DRDO for the lab.

The microscopes at IISc have also helped train generations of budding scientists, Kamanio points out. "If you go anywhere in India and look at people doing microscopy, chances are that many of them were trained here," he says. "TEM at IISc has a legacy dating back to the 1950s. And that is something which no place else has."

Vivek Kumar is an Integrated PhD student in the Department of Physics, IISc and a science writing intern at the Office of Communications

Beyond Brick and Mortar

- Bitasta Das

Photo courtesy: CST

Unique centre at IISc's Challakere campus exemplifies sustainable construction

Aerial view of C-BELT's academic and training complex

The temperature was a sizzling 40°C on the morning of 24 April when I reached the IISc campus in Challakere. Summers in this area have become worse in recent years. The sweltering heat was becoming unbearable as I made my way past various buildings to reach the Centre for Bio-Energy and Low Carbon Technologies (C-BELT).

The gate leading to C-BELT is a sturdy 4.5 m wide structure, with a canopy allowing enough space for employees to park their two wheelers to escape the scorching sun. I noticed a group of people chatting under it. "It is cool and breezy here," one of them said. That's when I realised that it was indeed significantly cooler under the gate than the rest of the campus. The walls of the gate are made of stabilised Compressed Earth Blocks (CEB) with a jack arch roof, techniques that merge environmental consciousness with energy efficiency, producing structures that provide comfort to the dwellers.

Moving past the gate and coming upon the cluster of buildings that make up the C-BELT, I could not help being awed by the aesthetics of the construction. The earthy and rustic-looking, yet contemporary architecture was a marvel to behold. Despite the blistering heat, the buildings were cool and airy inside. All the buildings within the C-BELT are a standing example of the advantages offered by sustainable construction technologies.

Photo courtesy: CST

The exhibition centre built with Rubble Rock Masonry (RRM) technique

The C-BELT project is an initiative of the Centre for Sustainable Technologies (CST) at IISc, which completes 50 years of its existence this year. Over its lifetime, CST has focused on developing low-carbon and energy-efficient technologies to bring about environmentally friendly, economically efficient, and socially responsible innovations, mainly in rural and peri-urban regions.

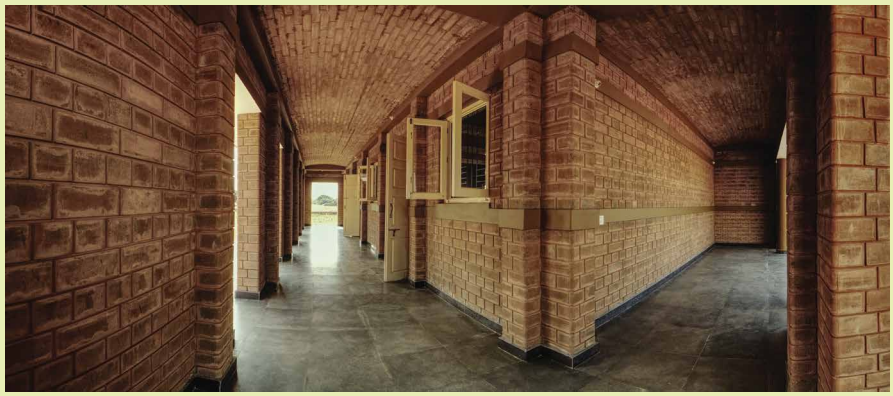
> ***"The earthy and rustic-looking, yet contemporary architecture was a marvel to behold"***

In the last five decades, its researchers have worked on diverse areas including energy, buildings and habitats, solid waste utilisation, water and wastewater treatment, and more. This has resulted in the development of several sustainable technologies that have generated employment for communities across Karnataka as well as in many other states of the country.

Building on this legacy, CST decided to launch C-BELT in 2015 with an initial seed grant from the Department of IT-BT, Government of Karnataka, and later with CSR funds received from the HT Parekh Foundation. BV Venkatarama Reddy, then Chair of CST, and other faculty members spearheaded C-BELT. Reddy, Monto Mani (Professor) and SN Ullas (Senior Project Scientist), along with architect Mala Sugantha, led the construction of the C-BELT capacity building centre. It took two years to complete.

Photo courtesy: CST

Laboratory building's dome without central support



Classroom walls built with stabilised Compressed Earth Blocks (CEB)

Reducing carbon footprint

There were two main objectives for setting up C-BELT at Challakere. The first was to have a permanent set-up where training and workshops can be conducted on sustainable technologies, which, until 2015 were being carried out at many different places, including the IISc Bangalore campus. The second was to build relationships with the villages and communities nearby, by constructing buildings that the latter required, like community centres and sanitation units using sustainable technologies. The CST team realised that such a space could help train the local communities to develop their own technologies. But they were not satisfied with just regular buildings that could house these activities. They wanted the buildings to be built using sustainable technologies, as a direct demonstration of their efficiency and to showcase CST's own contributions.

"The deployment of sustainable technologies started right from building the campus boundary wall at Challakere," says Reddy. About 4.5 km of the 10 km boundary wall of the campus has been built using rubble stones that were found in the arid land of the Challakere campus using a sustainable Random Rubble Masonry (RRM) technique. RRM involves the use of irregularly shaped stone boulders arranged randomly and packing the crevices with flowable earth mix mortar. The C-BELT buildings used climate responsive naturally conditioned building concepts with low-carbon materials. The impact of sustainable technologies is clearly evident – I did not spot a single air conditioning unit in the buildings of C-BELT.

> ***The impact of sustainable technologies is clearly evident – I did not spot a single air conditioning unit in the buildings***

The raw material used to build the Centre included locally available rocks, soil and gravel as an alternative to more polluting materials like glass and concrete. The Centre has several multi-purpose buildings that serve as demonstration units, showcasing how the use of low-carbon materials can create more habitable structures for visitors and trainees. One of these buildings is an academic and training complex which has a classroom, a laboratory, an office, an exhibition centre, a workshop demonstration unit, and a water storage unit. The residential area has a dormitory complex that can accommodate 30 people and a house for a caretaker.

"The premise was initially bustling with activity," says Hemanthkumara R, a civil engineer who is in charge of maintaining the C-BELT infrastructure. "However, the pandemic has hampered the momentum," he adds. Before the pandemic hit, two six day-long national-level residential training programmes were held.

Local and global impact

When IISc obtained the 1,500-acre campus at Challakere, the intent was to build relationships with local communities and give back something to the society, Reddy says. "We built community centres and sanitary units using pre-cast micro-concrete panels, and another type of sanitary unit using Flowable Earth Mix concrete. These are low-carbon sustainable and alternative methods of construction in these regions."

Villages like Gouripura and Nayakanahatti located in the vicinity of the IISc Challakere campus benefitted from this. Many households in these communities were trained and provided with fuel-efficient biomass cook stoves called ASTRA ole. "We took some small contribution from the local people, not monetarily, but in the form of labour and some raw materials, so that they feel a sense of ownership," Reddy adds.

Soon, the news spread in the vicinity and other villages too requested similar buildings. IISc has constructed about 20 sanitary units and four community centres in four villages so far. Several training programmes were conducted at the C-BELT. People who attended these workshops ranged from local farmers and villagers to engineers, architects and construction professionals, coming from far-flung regions like Uttarakhand and Chhattisgarh. Besides construction technologies and ASTRA ole, people are also trained in making devices like the ASTRA dryer, which is a dehydration device that facilitates drying fruits, vegetables and spices – this is particularly useful in damp and humid regions. Some participants have gone on to become entrepreneurs,

Photo: Bitasta Das

Machine for making Compressed Earth Blocks (CEB)

manufacturing and selling their own versions of these devices. Water treatment and removal of fluoride from water is another very popular training programme conducted at C-BELT.

With the threat of climate change accelerating across the world, there's an even greater need to expand the use of such sustainable technologies.

> ***The news spread in the vicinity and other villages too requested similar buildings***

Non-renewable resources like soil, metal ores, chemicals, limestone, oil and gas are fast depleting because of indiscriminate mining. The construction industry is a particularly notorious polluter, consuming about 45% of all natural resources and contributing heavily to the rising carbon emissions.

The sustainable technologies developed and demonstrated at C-BELT provide a viable alternative to this carbon-intensive contemporary construction. Besides the RRM method, other sustainable building technologies that they have developed include cement-stabilised Compressed Earth Blocks (CEB), stabilised earth mortar, filler slab roofs, cavity cool roofs, stabilised rammed earth, and so on.

For example, the CEB is a high-density (>1.8 g/cc) block, manufactured by compacting earth or compressing a partially saturated processed mixture of soil, sand and stabiliser. They are produced from natural materials, primarily soil, which is abundant and renewable. Their production requires minimal energy compared to traditional building materials like bricks or concrete, reducing carbon emissions associated with manufacturing. The machine that produces CEB employs a static compaction process. These machines were designed from scratch by CST researchers.

The adoption of sustainable technologies not only calls for efforts of researchers, but also requires policy support, public awareness campaigns and market incentives. Reddy says that the Centre is currently seeking funds to sustain its maintenance and increase the scope of its activities.

Notably, most of the technologies being developed at C-BELT are not patented, so that they can be freely disseminated to everyone. Care has also been taken to ensure that these technologies and products stand the test of time.

> ***Most of the technologies being developed at C-BELT are not patented, so that they can be freely disseminated***

Reddy recalls an incident about 12 years ago, when there were heavy rains just after the boundary wall was erected around the Challakere campus using RRM. Some of the personnel there were unsure whether the wall would survive the downpour as they had used an unconventional method to build it, using minimal cement and rubble stones. Not only did the wall withstand that torrent but it has also remained steadfast for more than a decade. In recent years, many architect visitors have adopted this technique to build commercial and residential buildings.

Sustainable technologies, at their core, seek to conserve nature and mitigate climate change. It is only prudent that these technologies are increasingly implemented to counter the environmental degradation that has happened in the recent past. C-BELT is an illustrative example of how sustainable technologies can merge charm and aesthetics with energy efficiency and cost effectiveness.

Photos: Bitasta Das

Sanitary Unit and Community Centre at Nayakanahatti

Keeping up with Veeranna

- *Ananthapathmanabhan MS*

Photo: Ananthapathmanabhan MS

CONNECT *spent a day with a Deputy Registrar who wears many hats*

For Veeranna Kammar, "seeing is believing"– a mantra he learned from his first job as a journalist. Veeranna's first job, as a sub-editor in the Kannada daily *Prajavani* in 1998, came before he even completed his post-graduation degree.

In 2015, he joined IISc as an Assistant Registrar. Now serving as the Deputy Registrar for Gymkhana, Campus Support Services, Guest House, Amenities, and Public Relations at IISc, Veeranna asserts: "Once a journalist, always a journalist."

It is this curiosity that drives Veeranna to be present in person at various spots on campus. Veeranna easily completes 10,000 steps every day, visiting spaces around the Institute, from the amenity centres to the sports ground.

He is up at 6 am every morning. The day starts not with a coffee but with a throat-clearing *kashaya* mix.

For breakfast, he prefers to eat ragi and rice-based items made at home.

By 9 am, he is at work. On this day, his first visit is to the solid waste management premises and he meticulously examines the area, asking the workers about the segregation and amount of waste that were received the previous day. It is straight to the swimming pool next, about 100 m down the road. The pool is temporarily closed due to the ongoing water crisis, but Veeranna has to make sure that things are maintained well.

> ***Veeranna easily completes 10,000 steps every day, visiting spaces around the Institute***

"We do not know when the water supply will resume. So, we must be ready to open the pool if the authorities instruct us to tomorrow," Veeranna reiterates to the pool staff. He heads into the filtration room, checking to see if everything is maintained well.

While thick dirty water is pumped out as the drain pipe gets cleaned, Veeranna heads to the other side of the room to check if the sand-bed filter is in place. There is never a moment of hesitation in clarifying with the pool staff even about the smallest of doubts.

"If I see something new, I am very curious to know about it. That curiosity will lead you to learn and experience a lot of new things," he explains, as we head towards the IISc Guest House, another facility under his purview. "While walking, I will visit some places and I will make a mind map of 'requirements on a particular day,'" he reveals. It helps him prioritise his day.

As he trots down the roads, he talks about his former life as a journalist.

"In the mornings, I used to go to college. We had a good mess in the *Deccan Herald-Prajavani* office, and we used to have lunch there and start the newspaper work around 3 pm," says Veeranna.

> ***'I encounter a lot of students and ask them about their specialisation and their thesis'***

After earning his journalism degree, Veeranna continued to work for the newspaper for seven years, learning the ropes and developing a healthy appreciation for the art of telling stories.

When he eventually left journalism in 2005, he joined the information and publicity department of the Karnataka Government.

"Initially, I was posted in Bijapur for more than a year, then I was transferred to Delhi," he reveals. He was in the capital for four years after which he returned to Bangalore for a year-long stint at the Karnataka Chief Minister's media wing. He then took a job as an Assistant Registrar at Karnataka Central University before moving to IISc.

As we approach the guest house, Vipin, an administrative assistant, comes out of his cabin to have a conversation with Veeranna.

As he continues to walk around the campus, students greet him. Immensely popular among the students, Veeranna has plenty of time for the youngsters. "Every day, I encounter a lot of students and I ask them about their specialisation and their thesis," says Veeranna, smiling. "One student was telling me about tectonic plates which I got interested in. I will ask him about it again."

He finds every day on campus refreshing. “I stay in the campus quarters and today I woke up to a peacock's song. There are also a lot of flowers. It is very safe as well,” he says.

For Veeranna, staying on campus offers a sense of belonging, as he chances upon many people at IISc including faculty, students, workers, and frequent visitors at his Public Relations Office.

At 10 am, he reaches his office, and nodding to his colleagues, he pops into his cabin and turns on his computer. On the wall is a spread of the top view of the upcoming sports ground at the Institute. He checks his emails, focusing on the upcoming Spectrum interdepartmental sports fest, as he prepares for a meeting with the students at the Gymkhana in the evening.

Apart from overseeing Public Relations, he also heads other sections. So, signing documents related to tenders from various vendors is part of his job. Veeranna rings the bell, beckoning a staff member to check the forms related to a recent tender document. As he makes corrections to the content, his phone rings. The call is from the National Building Construction Corporation seeking an office space on campus. Before he could finish the call, another call chimes in, with the speaker wanting to discuss the inaugural ceremony of Spectrum. Next, he dials the Director’s office to see if the Director is available for the next day’s torch run, to kick off the sports fest. He rings the table bell again and the office assistant, Manjula, arrives. Another tender document. Eyebrows scrunched, he reads it carefully, flagging any loopholes.

He then gets up from his chair to visit the Janata Bazaar, where some of the sports and recreational facilities are to be shifted, but is interrupted by another call and a visitor. He sits down again to receive them.

“As a government servant, I must serve them [visitors] to the best of my knowledge,” Veeranna says.

Two more people arrive, seeking clarity on how to join IISc for an academic programme. Veeranna asks the whereabouts and interests of the student, before suggesting that they explore the JEE mains and advises them to join the new BTech in Mathematics and Computing course in IISc.

He makes another phone call, this time to a person named Anoop, who is the Assistant Registrar at the Academic Section. Veeranna suggests that the visitors meet Anoop for further clarity.

He gets up from his chair, seeing the visitors off as he heads out. Just outside of the office, he runs into two people standing by to meet him. He greets them with warm handshakes and carries on a short conversation with them. At the end of the conversation, he gets another call, one he cannot take at the moment. Right away, there are four visitors in person and another one on the phone. Veeranna handles the small crowd seamlessly. He concludes the conversations and ensures the visitors are led to places where they can find what they need and sets out to visit the Main Building where a quick meeting with one of the Deans is set to start in minutes.

Photo: Ananthapathmanabhan MS

Veeranna in discussion with student representatives for various sports events

It is noon. The meeting with the Dean is over. Veeranna walks towards Janata Bazaar to check out the new space coming up for recreational activities like Zumba, yoga, dance and so on. He calls Manjula and requests her to bring the keys. The building is also known as the North Campus Amenity Centre. He, along with Manjula, makes sure that the lights, fans and plug points are all working. He claps in the empty hall to check for echoes. It is not just about room acoustics, he is also keen to know how much cross-ventilation the room has so that people will be at ease in the studio. Next, he walks to check the eatery at the Department of Electrical Communication Engineering (ECE). With the canteen staff, he enquires about the cost of the food and the daily business. Before he breaks for lunch, he once again confirms the evening meeting at the Gymkhana.

> ***A former journalist, he believes in being present and engaging with workers, staff, and students***

Often, Veeranna puts off lunch for a later time as work tends to spring up during the course of the day. But today, he can eat lunch around 1 pm. Veeranna prefers a north Karnataka diet that includes chapati, rice, and sabzi. After lunch at his home, he is back to his desk to resume work. He goes about documenting his work forms, checking some, and delegating others. As a former journalist, he believes in being present in person and engaging with workers, staff, and students to make sure things are all set.

A staff member steps into his office, with a public relations document. He sifts through the document and signs it. He gets another call from the Director’s office saying that the Director has agreed to inaugurate Spectrum.

He checks the time – it is five minutes to his meeting – and sets out towards the Gymkhana. He is interrupted by another document to be scanned and approved. As soon as he is done, Anoop calls him and enquires about some finer points regarding the Students' Council election dates. After glancing at the computer screen to check for any new emails,

Photo: Ananthapathmanabhan MS

Veeranna Kammar chats with the ground workers at the sports ground

Veeranna closes the array of tabs in the browser and sets out towards the Gymkhana. It is now 15 minutes past five in the evening.

As soon as he walks over the bridge that connects the main campus and the Gymkhana, Veeranna is greeted by students passing by and the staff at the sports centre. He responds with a smile, mirroring the greetings. He asks a Gymkhana staff member to prepare for the meeting. In 10 minutes, all the student representatives are present and the meeting starts.

Veeranna does not believe in micromanaging, as he delegates. He even encourages the student representatives to delegate some work to other members so that they can stave away the pressure. Together, they set up the agenda for the inaugural meeting: the opening ceremony, torch run and regrouping at the inaugural space for the closing ceremony. He makes sure that the representatives are aware of what needs to be done and by what time each checkpoint on the agenda should be finished. Before he finishes the meeting, he makes a call to the photographer, KG Haridasan, to arrange for pictures of the event. He walks out of the meeting room and checks on the amenities at the Gymkhana. He stops by the dance room and the instructor, Devajani Sen, invites him to visit for an upcoming event. He assures her of his presence, enquires about the dance classes, and makes sure that the teacher feels heard.

He comes out of the building and walks towards the tennis court. A new court is coming up in addition to the existing court. He eyes the construction work. On his way to the cricket ground, he is greeted by three students. They ask about the upcoming grounds. Veeranna explains the ongoing work and the expected date of completion. Although concerned by the delay, the students are convinced by Veeranna's explanation.

He continues to walk towards the student amenity centre and walks onto the stage where preparations related to a freshers' event are ongoing. Two students quickly approach him and say, "Thank you very much, sir, for your help." They are members of the music band Rhythmica, expressing their gratitude towards Veeranna who helped set up their previous event. He spends around 10 minutes with the students and encourages them to be involved in more extracurricular programmes beyond academia.

Clearly, Veeranna is a people person. Nonetheless, when it comes to work, he is a man of rules.

"Since the beginning of my career in the government sector, I have been treated as a man of rules by my colleagues. I will not violate any rule ... Even if I want to help [people], I cannot help if the rule does not permit me to do so," says Veeranna. "Even if you are friendly, even if you are jovial, if you follow the rules, nothing will happen. That is my belief."

The day is winding up, the campus lights are turning on. It is seven in the evening when Veeranna decides to call it a day. He sets off to his house, where there are plants to be watered.

Scientists on Sci-fi

- Sandeep Menon

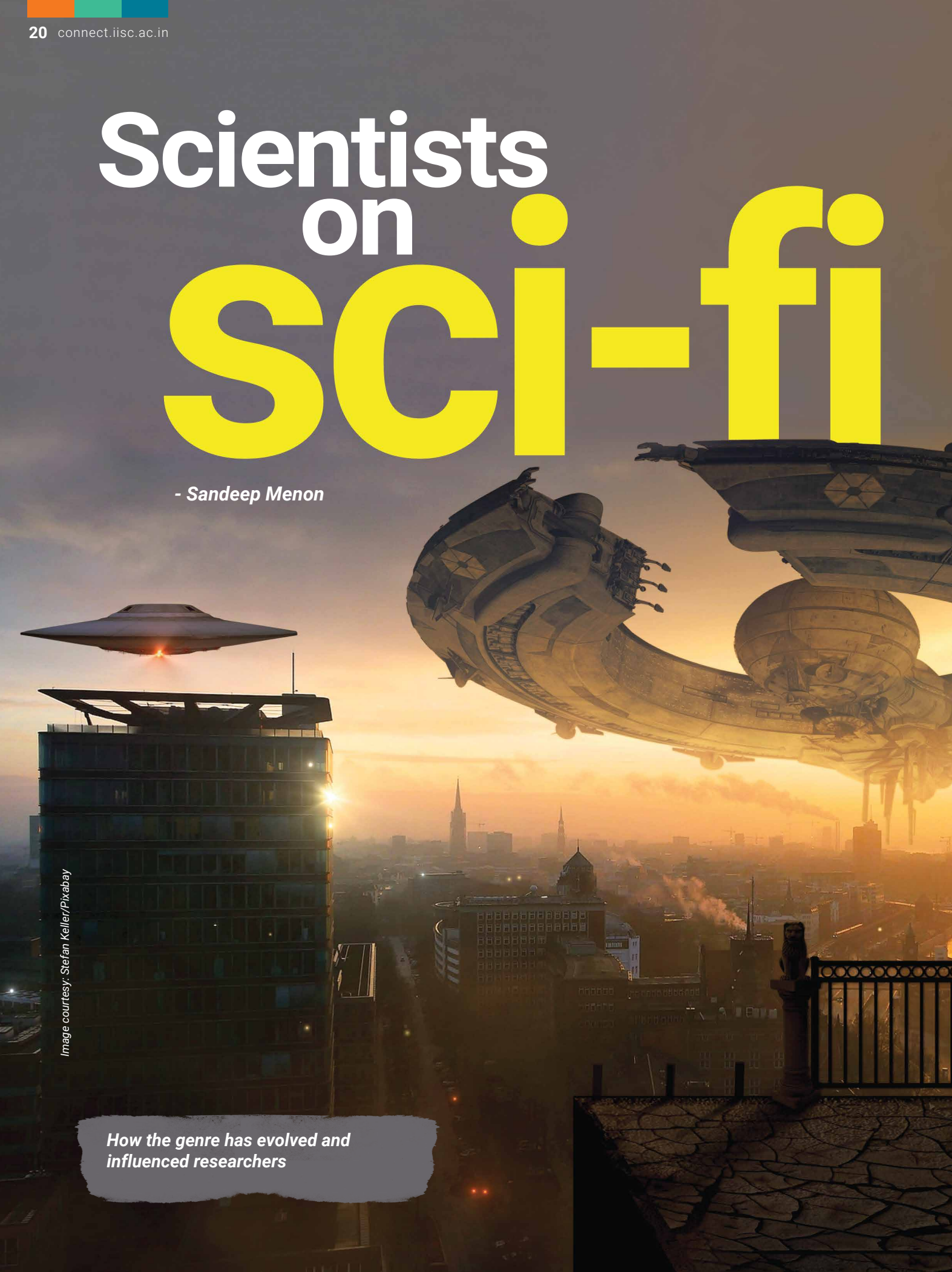


Image courtesy: Stefan Keller/Pixabay

How the genre has evolved and influenced researchers

It was early 2005. GK Ananthasuresh had joined IISc a few months before. His neighbour in the campus quarters then was Utpal Nath, another faculty member who was researching gene mutations in plant leaves. It was known that certain genes are responsible for facilitating differential growth rates in leaves, which decides their shapes. An effort was being made to manipulate the genes to see if the leaves could be completely curved irregularly at the edges, like that of lettuce, or become regularly shaped cups. Engineering had to kick in to turn the leaves into any desired shape. It was just taking a lot of time, as these things tend to do.

This got Ananthasuresh thinking, his imagination building steam. Looping in his ideas of sustainability, he began writing a science fiction story in Telugu about a genetically modified tree with leaves naturally shaped as cups, plates, and cutlery. '*Vichitra pathram*,' he called it. His short story was published by the Telugu Association of North America. Years later, now the Dean of the Division of Mechanical Sciences at IISc, he recounts the story with a smile.

"Science fiction is all about imagination. You can wonder about the underlying principles based on your own knowledge. To use those ideas in research, much more scrutiny and rigour are needed," he says. "Science fiction might inspire you when you are young and impressionable, but as we grow older and learn more, we are more sceptical about how much science fiction inspires research."

Science fiction has long remained literature's under-appreciated child, eliciting a certain uppity smirk from purists. It is a genre that often comes into the readers' lives during their early teens, before gently exiting, in many cases, a few years later. A pit-stop, to be remembered fondly as an emblem of a simpler time or when a new television series or movie brings the topic back in vogue again.

Peel back the layers a bit, and science fiction packs a punch. It foreshadows what science and scientists can potentially do, cheerleading the latter to make the fiction a reality.

The genre's pioneering work is often considered to be Mary Shelley's *Frankenstein*, which was written in the early 19th century. But it truly took off when authors like Jules Verne and HG Wells came out with their works, writ with fascination for the abundant possibilities as scientific fields sprung anew.

Science fiction evolved further in the mid-1900s as modern technology, from air travel to nuclear weapons, was making strides in shaping the new world. Christened the Golden Age of science fiction, the literature also depicted themes of adventure and exploration.

"Classic science fiction was visionary, it was hopeful. Certainly, it started with physics as the primary thrust. You go to other worlds, [on] spaceships, and so on," remarks Jayant Murthy, an astrophysicist at the Indian Institute of Astrophysics (IIA). "It was the time when technology was evolving, and we thought it would lead us to the heavens. It must have been an amazing

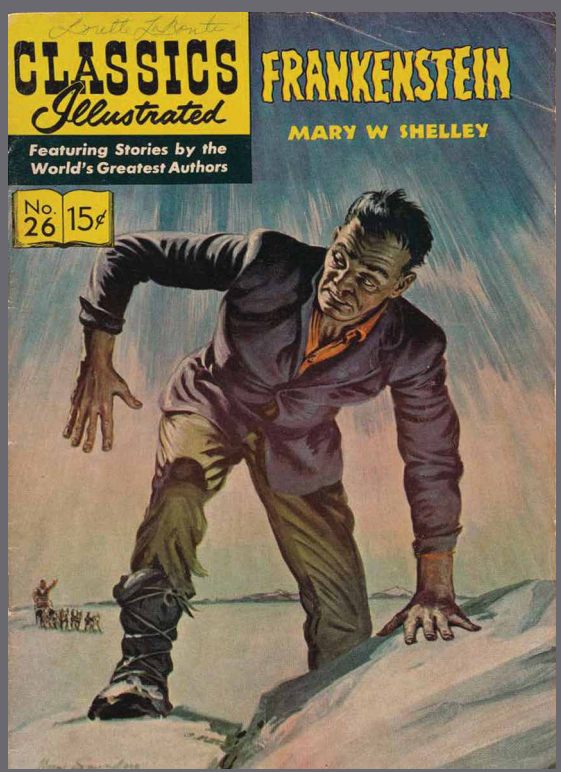


Photo courtesy: Picryl

Mary Shelley's Frankenstein (1818) is often considered the first work of science fiction

time because you saw so many new things coming up. Perhaps we don't have that sense of wonder anymore because we know that it is more complicated, and that some of the technology we have created is problematic."

> ***Science fiction foreshadows what science and scientists can potentially do, cheerleading the latter to make the fiction a reality***

It was during this time that Issac Asimov wrote his famous *Foundation* and *Robot* series which ventured into the future of robotics. The literature, already rich with iconic works like *War of the Worlds*, *The Time Machine* and more, was further enriched. Viewing the future through the tint of the ongoing Cold War, science fiction – with its promise of a bright future and grandeur – provided an escape.

Over the next half century, the genre evolved to include a more complicated and experimental approach, with a stronger focus on characters and narratives. Philip K Dick questioned the concept of reality in his works, and Ursula K Le Guin, the author of the famed *Earthsea* series, portrayed a strong representation of gender and sexuality in her writing. This was a departure from much of the old science fiction which conformed with the racial hierarchies of the time and had little representation of minority groups.

The socio-political structure of the time seeped into the story, often telling tales of people set in the backdrop of a fictional world of make-believe science. The explosive success of *Star Wars, Star Trek* and other movies and series took the genre to even further heights in the current era, where it is no longer shoved into a corner of popular culture. The 21st century is the "Era of the Nerds". Where once the term was used derisively, it is works of science fiction, fantasy and action comics that now command the highest budgets and the biggest returns.

Making an impact

According to some scientists, science fiction has remained a pillar of social discourse in some of the elite science institutes in the country, especially at the end of the 20th century. It is possible that this trend may have reduced with fewer students gathering in communal areas, such as TV rooms and common areas of hostels, thanks to mobile phones and social media. But science fiction's impact on science and scientists often came before they reached these institutions.

"Science fiction made a substantial impression on me," admits Nirmal Raj, Assistant Professor at IISc's Centre for High Energy Physics.

The works of Asimov and Arthur C Clarke inspired Nirmal to become a scientist and a writer (he writes science columns for *The Hindu*). It would be churlish, however, to give science fiction all the credit for it. Often, science fiction is but a catalyst or nudge in the right direction. Nirmal also had an environment in his educational institutions that nurtured his curiosity and did not belittle it.

"What science fiction did was it got me excited about science without knowing much about science," Nirmal says. "It gave me an image of what science could be. It gave me a vibe of an extremely exciting world out there. So, when I started working as a scientist, I did not need motivation. The same vibe was there. I feel it [even] now in my work where calculations and mathematics are my tools."

> ***'Science fiction got me excited about science without knowing much about science'***

Aloke Kumar, Associate Professor in the Department of Mechanical Engineering, is another convert.

"[Science fiction] opened my mind to fantastical ideas. Real science is hard, it takes a while for a child to understand and access it. Science fiction broke things down, it happened fast – you meet aliens at warp speed," Aloke says, with a smile. "It made me want to discover these things and be a part of it. Once I became proficient, I realised that fantastical things won't happen, experiments go wrong, and everything takes time."

From imagination to reality

While some have been inspired to pursue science, many have gone a step further in their attempt to make what they found in science fiction into reality. Jules Verne's *20,000 Leagues Under the Sea* was Simon Lake's inspiration to ideate the submarine for undersea travel. Verne's *Clipper of the Clouds* provided Igor Sikorsky the vision to think of the helicopter. *War of the Worlds* by HG Wells was the spark that led to Robert H Goddard building the first liquid-fuelled rocket. Motorola's first mobile phone borrowed the idea from Captain Kirk's communicator from *Star Trek*. The series also inspired the multimedia programme *QuickTime*, and the replicators shown in the series aided in the invention of 3D printing.

Ambarish Ghosh, Professor at the Centre for Nano Science and Engineeering, IISc, too, found inspiration from the 1966 film *Fantastic Voyage*. "The movie refers to a team of doctors miniaturised to travel through a human body and perform therapeutic tasks," he says. "The movie

Photo courtesy: Wikimedia Commons/David B Spalding

Star Trek*'s Communicator that inspired the first mobile phone*

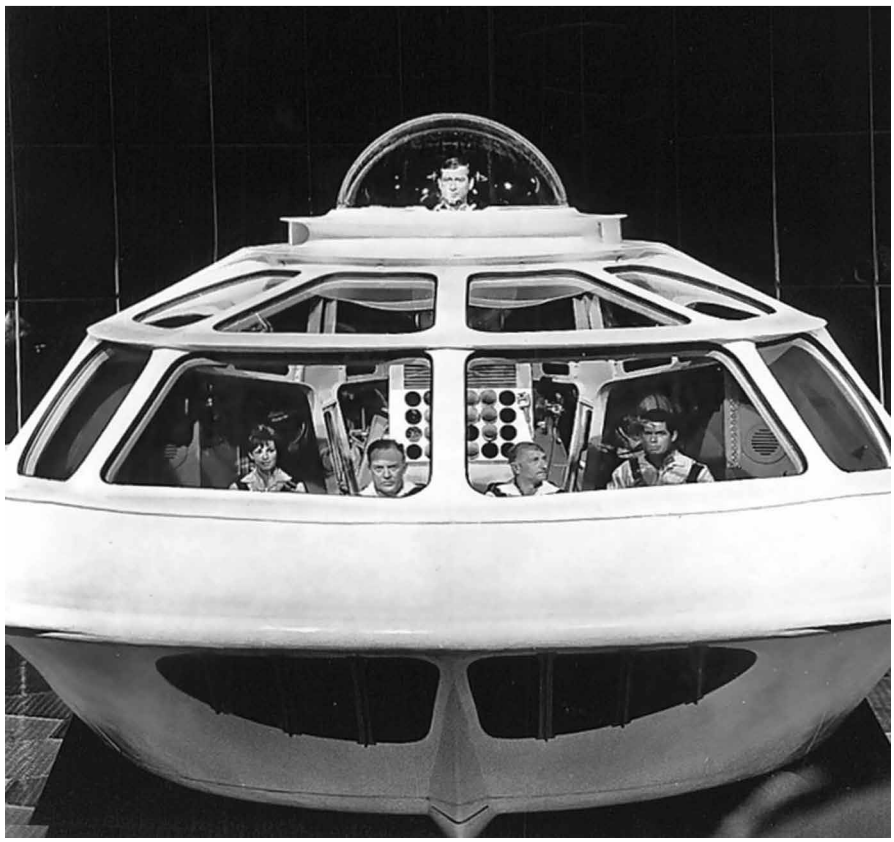


Photo courtesy: James Vaughan/Flickr

In the film Fantastic Voyage *(1966), doctors are miniaturised to enter and treat human bodies*

itself is preceded by a famous lecture by [Richard] Feynman called 'Plenty of room at the bottom.' The lecture, and later the movie, inspired many of us to work on small-sized, multifunctional robots that can be programmed to perform therapeutic tasks in living beings."

It is the power of the idea that leaves the deepest mark.

"In science, we look at things one step at a time. But science fiction allows a vision with results produced quickly," says Rajesh V Iyer, scientist at the Tata Institute for Genetics and Society (TIGS). "Science fiction often seeds an idea that we then try and reach. The stories on robotics written in the 1960s are now a reality. [And so are] mobile technology and self-driven cars."

Michael Crichton's *Jurassic Park*, immortalised on the silver screen by Steven Spielberg, made genetic engineering a part of common parlance in the 1990s. Three decades on, scientists are working on reviving the woolly mammoth, the modern elephant's long-extinct ice-age cousin.

The quintessential final evolved image of Artificial Intelligence might just be something akin to HAL (Heuristically Programmed Algorithmic Computer) 9000 – minus the antagonist tendencies – from *2001: A Space Odyssey* by Arthur C Clarke, or TARS from the movie *Interstellar*, where AI behaves akin to humans. There is little doubt that such images – and aspirations to build such machines – are in the minds of young researchers.

Sahil Bobade, an MTech student in Robotics and Autonomous Systems in IISc, was drawn to follow his passion after watching robots exhibiting intelligent behaviour, like those from the film *Chappie*. "I wanted to know more about it. My final year project is about imitation learning," he says.

His classmate Mehul Nakre found his fascination with automation.
"I enquired about courses in India in that field and I found IISc," Mehul says. "My project is automating agriculture with multiagent systems, drones, and other things that can make decisions. Seeing movies, we know what the best-case scenario is, and we are moving towards that."

Science fiction stories also act as cautionary tales, warning humanity of the perils of man trying to play God, with lines such as the famous "Life finds a way" by mathematician Ian Malcolm in *Jurassic Park*. It is a common trope that forms part of the emotional and moral dilemma in many works of science fiction.

Technology and science will always go forward. They will be nothing more than a tool. The heart and morality of humans is what gives them meaning. And that is what makes science fiction so appealing, explaining the humanity and challenges of advancing technology, a delicate balance. There is great care taken by those who produce works of science fiction now to make sure that they get the facts right – like how renowned scientist Kip Thorne advised director Chris Nolan on *Interstellar*. The hope is to get the science in fiction right, in addition to attracting the masses. As Mark Twain once said: "Get your facts first, then you can distort them as you please."

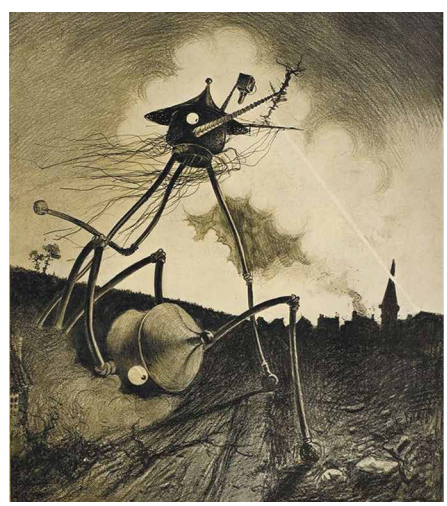


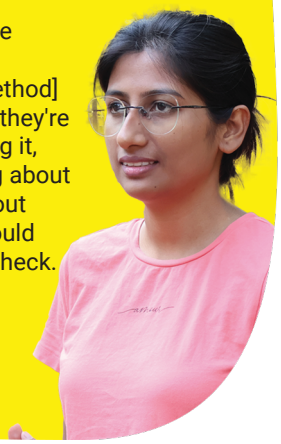
Photo courtesy: Henrique Alvim-Corrêa/ NASA Goddard Space Flight Centre

War of the Worlds *(left) by HG Wells inspired scientist Robert H Goddard to build the first liquid-fuelled rocket (right) in 1926*

CONNECT ASKS

"What concepts fiction have

"There's a horror sci-fi movie called *Life*. It shows the reality that if you go after everything that comes in front of you, you might end up in a mess. In this story [Spoiler Alert!], they [scientists] plan to bring a living cell from Mars to Earth. Initially, they were very happy. They name it Charlie. They're feeding it, talking to it, and it grows and grows. But in the middle of their trip, they realise that the entity has the ability to overpower all of them, and that it must not land on Earth. But unfortunately, it does. And that's where the story ends. The film shows you don't have to pursue whatever is unknown, and that curiosity kills. This film is grounding, I feel. All these technologies like CRISPR-Cas9 [a gene-editing method] and everything, they're just blindly doing it, without thinking about what if it turns out wrong? You should always have a check.



Prachi Priya
PhD student in Biochemistry

"When I was kid there was a cartoon show called *Buzz Lightyear*. It was like a preliminary experience with science for me. It was really interesting because Lightyear was a commanding officer, and he used to visit different planets and see how life was there, finding so many other galaxies. Then as I grew up, a lot of other things came up. Like the movie *Interstellar*. It's a very good movie to watch if you know physics. If you don't know physics, then you're just watching a screen (*laughs*). I've seen how sci-fi has evolved from magazines and comic books to cartoons to movies now.

Ankush Kumar Sharma
PhD student in Bioengineering

"There's a movie called In *Time*, where everyone has an ingrained timer on their hand, and when it runs out, they will die. There are also social hierarchies, some people will have a million years, but some workers will have much less. You can borrow time at banks. At work, time is your wage … It's really interesting. I would like the ability to know how much time you have left.

Saikiran Pandit
PhD student in Electrical Engineering

"*Tenet* is a movie that comes to mind. It's very confusing! It's like some people move forward in time and also can move backward in time; it talks about "inversion" where we can move backwards while the world we know moves forward. Other time travel movies like *Predestination* and *Inception* are at least perceivable. But *Tenet*, it's very difficult to grasp the entirety of it. After seeing the movie I came and watched many YouTube explanations, but still don't fully get it (*laughs*). Another movie is *Coherence*. It is just happening in one room. A comet passes and something happens, and there are multiple versions of the same person in different realities and they can co-exist and interact with their counterparts. Most of these movies are something related with time. Probably if I could have one of these [abilities] in real life, I would say at this point, it's "more time". It seems like the most precious resource we can have these days.

Meenu Jayamohan
PhD student in Electrical Engineering

"There's a series called *Dark*. It's about time travel, and going back in time to rectify your mistakes. I watched it during the 2020 COVID lockdown. The protagonist's father dies and he goes back in time to stop that. The main message of the movie was kind of like 'how the end is the beginning and everyone is connected'. I've watched many time travel movies, like *Inception*, and other Christopher Nolan films. If I could time travel, I'd probably go back in time and study properly (*laughs*).

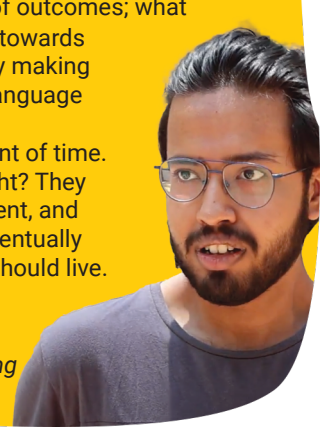
Anusri Saha
PhD student in Earth Sciences

in science intrigued you?"

"I'm a huge fan of Dan Brown books. And movies like *Tenet*, *Interstellar*, the series *Dark*. What interests me the most about sci-fi is how they conceptualise fiction in such a way that it almost seems possible; like maybe we are just one step away from making it into reality. *Interstellar* seemed pretty much possible. It's just that we don't have the technology to travel that far in space or have that much fuel or cross like wormholes or stuff like that yet. *Jurassic Park*, for instance, I mean that seems possible [at some point in the future]. But it's not just the technology that we don't have yet, it's also a lot of ethics that have to be considered while doing these sorts of experiments. For example, we do know how to make clones, exact genetic clones, but we cannot proceed with it because there are ethical considerations.

Sayantani Garai
MTech student in Bioengineering

"I've enjoyed watching many movies like *E.T.* and *Dune*. *Arrival* is another one that explores the concept of how we can use language and time in different ways. Stuff like that can change how we think about simple things in our daily life. I think the underlying message here is that we are in a precarious situation as a society, and we can either develop a good interplanetary civilisation or end up in a cyberpunk future. We have already thought of outcomes; what we need is a change in approach towards them. We don't have to be actively making time machines! Just make your language independent of time, and you will automatically become independent of time. That's what they say in *Arrival*, right? They remove the concept of past, present, and future from their language and eventually their lives. Maybe that's how we should live.



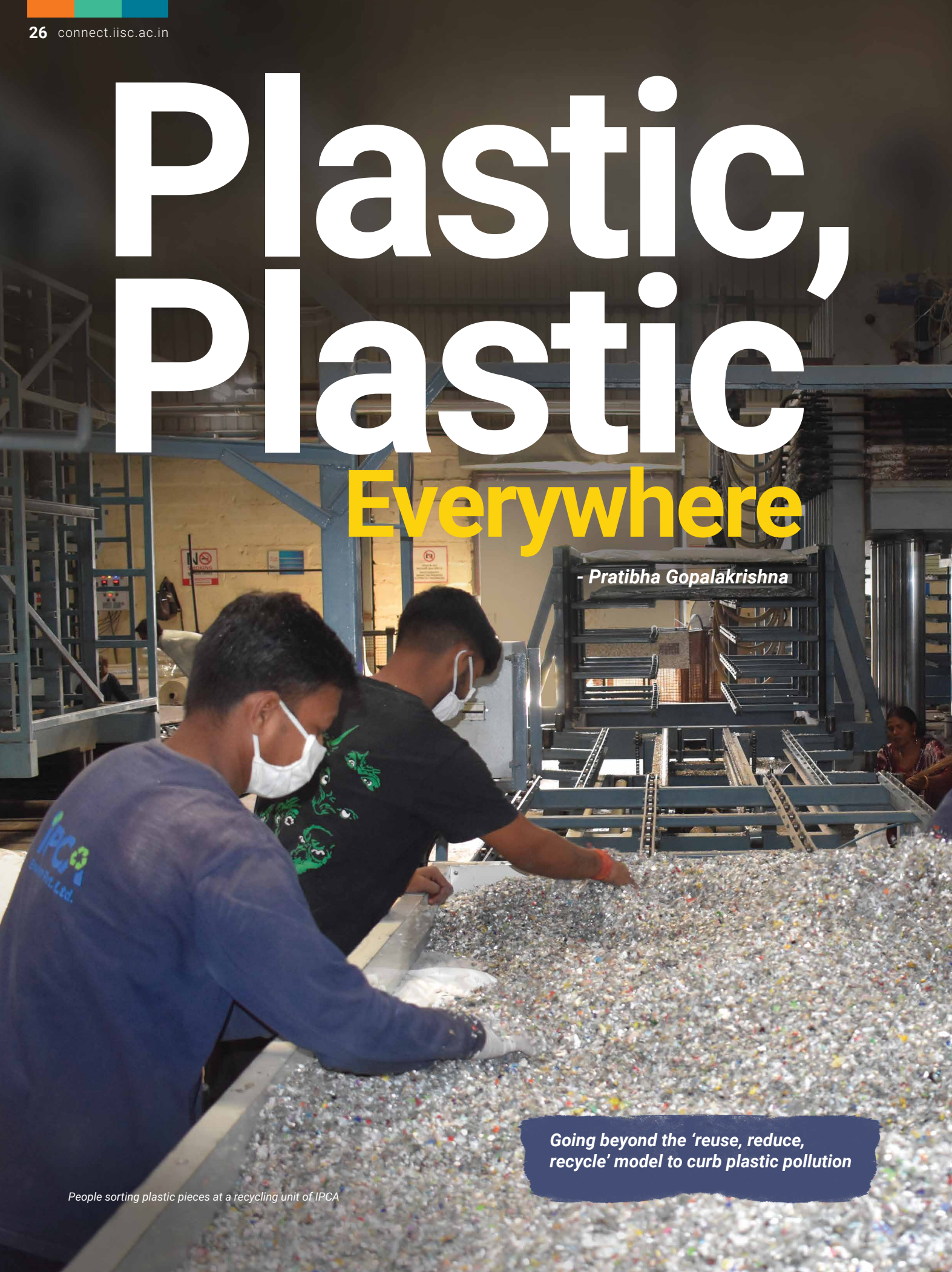
Rhitabrata Das
UG student in Materials Engineering

"Movies like *Interstellar* made me realise that time is a whole other dimension, which we don't realise when we live on Earth. There is also another nice movie I liked called *Her*, where the man falls in love with his AI chatbot. Interesting to think about this when we do have AI chatbots now like Chatgpt and Gemini. Another new sci-fi series I haven't seen yet but many have recommended to me is the *Three Body Problem*.

Vivek Kumar
MTech student in Artificial Intelligence

Plastic, Plastic Everywhere

- Pratibha Gopalakrishna



Going beyond the 'reuse, reduce, recycle' model to curb plastic pollution

People sorting plastic pieces at a recycling unit of IPCA


Photo courtesy: IPCA

I turn off the alarm on my *phone*, slowly wake up, turn the fan *switch* off, and head to the bathroom. I push paste out of a *tube* onto my *toothbrush*, and brush my teeth. Then, I scoop water out of a peach-coloured *bucket* with a faded white *mug* to wash my face. Five minutes into the day and I've already touched six things made from plastic.

Throughout the rest of the day, I continue to note down anything plastic I touch, as science writer and author Susan Freinkel did for her book *Plastic: A Toxic Love Story*. While she recorded a whopping 196 plastic items in a single day, I could spot 60. My little experiment made me realise just how much plastic permeates our lives in various forms.

Our World in Data, an online open-access data platform, says that global plastic production reached a staggering 460 million tonnes in 2019, doubling in the last two decades. In India, every person produces 8 kg of plastic waste each year; although a small number compared to other countries, it is still significant considering the mountain of challenges associated with managing this material.

> ***I realised just how much plastic permeates our lives in various forms***

Plastic is heavily villainised these days, but it was once a much-needed invention.

During the mid-1800s, elephants were killed for their ivory tusks which were then whittled down to make buttonhooks, piano keys, combs, and billiard balls. In 1863, a New York billiards supplier offered a handsome fortune to anyone who came up with an ivory alternative. John Wesley Hyatt, a 23-year-old printing press operator with a knack for invention, set up a shack behind his home and began experimenting. Five years later, he invented celluloid – a brittle substance created from plant cell walls (cellulose) that, while not hard enough for a billiards ball, had other uses like making combs, film strips and sunglasses.

The plastics boom began in 1907 when Leo Baekeland, a Belgian chemist, combined two chemicals – formaldehyde and phenol – under pressure, to create the first completely synthetic plastic, christened bakelite.

Over the years, several other plastics like nylon, teflon and polystyrene were invented. Plastics were cheap, durable and versatile compared to ivory tusks and tortoise shells. These properties made it easy to mass-produce telephones, radios, sunglasses, bullet-proof vests and so on.

> ***Plastic is heavily villainised these days, but it was once a much-needed invention***

But today, these very perks have turned into perils. The same plastics that were created to prevent the exploitation of wildlife are now choking these creatures, finding their way into dense forests, deep oceans, and even human blood.

Plastic in labs

The invention of plastics was a boon for research as well. With single-use plastics, scientists working in labs did not have to worry about contamination as they could discard and use fresh equipment for their experiments. These practices continue to this day in many labs across the world, with only a few exceptions.

But some scientists are also studying the impact of plastic waste generated in research.

"I've been doing research for almost 17 years, and we have been using plastics for a long time," says Venkatesan Iyer, Facility in-charge of the Central Imaging and Flow Cytometry facility at the National Centre for Biological Sciences (NCBS), Bangalore. Around 2018, Venkatesan came across an article that estimated that five million tonnes of plastic were consumed in life science research each year. He was concerned that these plastics could not be recycled due to contamination with biological matter. "No company will try to segregate [this plastic]," he explains.

Venkatesan started looking for reusable alternatives. In 2022, he started a company called GreenFocus Research Technologies which develops GreenDish, a type of cell culture dish made from medical-grade stainless steel, the same material used by surgeons in bone grafts. He unscrews the top portion of the dish to show how cells can be placed inside with a cover glass on top and the entire set-up can be placed in a live-cell imaging microscope. Once the cell has been imaged, only the cover glass is discarded. The dish is washed and autoclaved in high-pressure steam making it sterile for its next use.

"The dish can be reused hundreds of times. Even if the material is discarded, it can be recycled completely," says Venkatesan.

> ***GreenDish is a reusable type of cell culture dish made from medical-grade stainless steel***

In the same campus, about a hundred metres away, another scientist is looking at the problem from a different angle.

Kavyashree Manjunath's interest had always been in the field of medicine and drug discovery. But after her PhD in crystallography at IISc, she joined a structural biology team at the Centre for Chemical Biology and Therapeutics (CCBT) at the Institute for Stem Cell Science and Regenerative Medicine (InStem), Bangalore. A multidisciplinary centre, CCBT carried out extensive cell biology and crystallographic studies, screening several lakhs of compounds regularly. But one aspect caught Kavya's attention – the extent of plastic waste that was generated in the process. Though it seemed inevitable for any drug discovery lab, it made her wonder about the magnitude of plastic waste generated by science labs.

Photo courtesy: Venkatesan Iyer

The reusable GreenDish under a microscope

Kavya sifted through literature from the world of plastics to find some solution. She came across a study published in *Science* in which scientists discovered a bacteria in a recycling site in Japan that could "eat" polyethylene terephthalate (PET) polymers, and subsequently grow on PET waste. "I never thought there could be an enzyme which can degrade plastic," she says. Until then, the research had largely presented only mechanical and chemical/thermal recycling solutions to plastic waste.

Combining this newfound knowledge with her protein engineering expertise, Kavya heads a start-up called Apratima Biosolutions incubated at the Centre for Cellular and Molecular Platforms (C-CAMP), Bangalore. Its focus is on developing enzyme-based solutions to recycle PET plastics that are used in packaging foods and beverages, especially small-sized soft drinks, juice and water. One of their enzymes can break down almost 90% of PET in just 17 hours. The byproducts of this process, terephthalic acid (TPA) and ethylene glycol, can be purified and eventually used as raw materials to re-manufacture PET.

> ***One of their enzymes can break down almost 5 gm of PET in just 17 hours***

Using enzymes to degrade plastic is still nascent, says Kavya, with only a handful of companies working on it around the world, like Carbios in France, Protein Evolution in USA, and Samsara Eco in Australia. There are several challenges that these companies need to overcome. One is the varying degrees of crystallinity of PET waste. Crystalline PETs are opaque and rigid while amorphous PETs are clear and flexible. But these forms interchange depending on the temperature. The enzymes used currently cannot access the crystalline structures of PET in order to break them down. Another issue, Kavya points out, is finding ways to reduce the amount of enzyme required to depolymerise PET. Thirdly, the enzyme is not reusable. Separating the enzyme from the byproducts is an expensive process.

Once the pilot studies are approved, Kavya plans to partner with industries that can produce the enzyme in larger quantities and then take this technology to recycling industries. "It can be integrated with existing mechanical recycling industries," she says.

The recycling conundrum

Most people believe that if they put plastic waste in a particular bin, it will get recycled, says Kavya. "We never think about what actually happens beyond that point." The truth is that it is difficult to find out how much of discarded plastic reaches the recycling centres and how much ends up in landfills or oceans. According to a 2023 report by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), only about 8% of plastic consumed in India is recycled.

Aditya Kabra, founder and CEO of a greentech startup called ZeroPlast Labs, says that while plastic consumption is one problem, lack of waste segregation is another. "If we mix food waste with plastics or other recyclable things, it becomes extremely difficult to remove the recyclable material," he explains. Organic waste also generates methane when it reaches landfills, giving rise to more carbon emissions. "Once we have full scale waste management facilities along with segregation and proper regulations, I think we can reach up to 80-90% of recycling rates, especially for plastics," he says.

According to Deepanshi Gandherva, Assistant Manager, Communications, at the Indian Pollution Control Association (IPCA), as part of the Extended Producers Responsibility (EPR) guidelines that come under the 2016 Plastic Waste Management Rules, the Central Pollution Control Board (CPCB) mandated that producers, importers and brand owners (PIBOs) should develop a system to collect the plastic back from the environment. "But there was no clear action plan for the environmentally-sound collection of plastic waste," Deepanshi explains. So, in 2017, IPCA – a non-governmental organisation (NGO) – prepared and executed an EPR action plan starting with five brands, namely Pepsi, Dabur, Perfetti Van Melle, Dharampal Satyapal Ltd, and Nestle. Today, Deepanshi says that they work with more than 200 PIBOs to execute these EPR guidelines.

Several states like Maharashtra, Karnataka and Tamil Nadu have issued mandates to plastic manufacturing industries to stop the import, manufacture, sale and use of single-use plastics like polystyrene and expanded polystyrene. Government initiatives like *Meendum manjappai*, which promote using yellow cloth bags instead of single-use plastic bags, also show promise.

> ***Only about 8% of plastic consumed in India is recycled***

Even though the country is moving in the right direction regulation-wise, Kabra is concerned that hasty inventions of plastic alternatives may cause other problems. For example, many companies have started using plates made from bagasse (the dry pulpy fibrous material that remains after crushing sugarcane). But these contain a layer on top made of PFAS, a carcinogenic substance that is banned in Europe and the USA, but not in India.

A recent study, published in the journal *Environmental Science* and *Technology*, also revealed that plastic products have lower greenhouse gas emissions compared to their alternatives in 15 out of 16 applications, such as producing grocery bags, food packaging, milk containers, wet pet food containers, and so on. "What good is a shift away from plastic bags if the paper alternative emits more GHG emissions across the product life cycle?" the authors write.

"This haphazard shift towards alternative materials without studying the implications is where we are creating more harm to humans and the environment," Kabra adds.

Photo courtesy: Kavya Manjunath

Kavya Manjunath in her lab that focuses on recycling PET plastics with enzymes

Photo courtesy: Aditya Kabra, ZeroPlast Labs

Biocompostable pellets

The truth behind bioplastics

During his Bachelor's studies at the Indian Institute of Science Education and Research (IISER), Pune, Kabra used to go on plastic pick-up drives once every two months, and was appalled by the enormity of plastic items he'd encounter every time.

He thought of developing a material that could decompose just like an orange or banana peel. Soon after, he met Kadhiravan Shanmuganathan, a scientist at the CSIR-National Chemical Laboratory, who wanted to commercialise a biopolymer developed in his lab. The two started ZeroPlast Labs in 2019. The company developed compostable bioplastics using cellulose from crop residues – reducing waste for farmers as well as providing an alternative to virgin plastic.

Five years later, the company has now paused its operations. One reason, Kabra says, is that the carbon footprint is equivalent to oil-based plastics. This includes the energy used for developing raw materials which, in the case of bioplastics, includes fertilisers, land and water for the crops. "We don't see any benefit in using biobased or biodegradable materials over virgin plastics – the environmental impact is the same," he says.

Bioplastics are also less resistant to moisture, and so cannot be used like conventional plastics for protecting food. "There is a trade-off between barrier properties and compostability," Kabra says.

Another reason is that biodegradable or compostable plastics do not degrade naturally like fruit and vegetable peels. "Bioplastics require industrial composting facilities to degrade," Kabra says. There are no such facilities in the country that maintain the right moisture, temperature and environmental conditions for these bioplastics to break down fully. Eventually, they end up in landfills, lasting for hundreds of years, making them no better than oil-based plastics.

Towards a circular future

Plastics are not evil on their own. They do not leach into the environment, says Suryasarathi Bose, Professor at the Department of Materials Engineering, IISc. "But when it is not disposed of properly and subjected to environmental conditions, that's where the problem begins," he says. His lab focuses on designing new bioplastics that can be degraded without requiring industrial facilities, and finding ways to transform discarded plastics.

Using precursors from oils and cellulose from crop stubble, Suryasarathi's lab and collaborators have developed bioplastics, similar to Kabra's ZeroPlast Labs. But, according to Suryasarathi, these degrade completely without affecting the environment – they do not leach out harmful chemicals when buried under the ground.

When it comes to plastics, one of the most challenging types is the multi-layered plastics or MLPs. These have at least one layer of plastic with another layer made of aluminium, metal films, polymeric materials or paper. Supply chains for collecting and recycling this type of plastic did not exist as they were difficult to integrate into the collection system, says Deepanshi. Therefore, IPCA set up two units for recycling MLPs where they recycle over 900 metric tonnes of plastic waste in a month to develop chipboards – similar to plywood but resistant to termites, water and fire – that can be used to build utilitarian products.

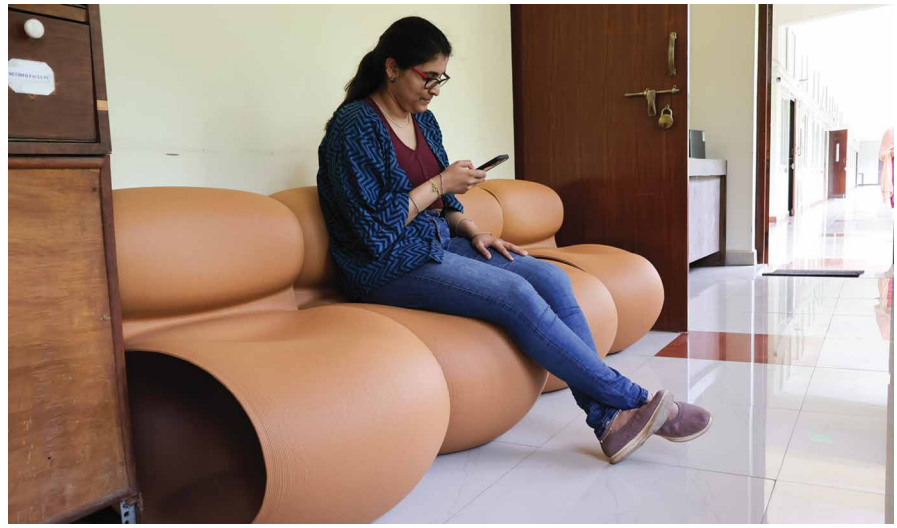


Photo: Abinaya Kalyanasundaram

Recycled furniture made of multi layered plastic (MLP) waste by VOiLA3D

Similarly, Suryasarathi is associated with VOiLA3D, a startup that collects MLPs and moulds them into useful products like furniture or pots. These can further be recycled so that they fit into the circular economy, he says. The concept of circular economy is designed around reusing or refurbishing materials as long as possible instead of the 'take-make-waste' linear model.

Suryasarathi adds that government support is important for creating awareness and bringing in policies. "For example, if there are kiosks made for returning all our shampoo bottles and oil containers, it is easier for a recycling plant to pick it up." As of now, NGOs like IPCA run several community engagement programmes to bring about behavioural changes in society towards segregating waste, zero littering and recycling.

While there are plenty of technologies and solutions being innovated, individuals can segregate waste to ensure it gets recycled for reducing plastic waste generation, says Kabra.

Beyond the three R's of recycling – reuse, reduce, recycle – we should add another 'R' called refuse, Venkatesan suggests. This can start with something as simple as refusing tea or coffee given in paper cups – which are usually coated with a thin layer of plastic – and asking for steel or glass cups which can be washed and reused.

As I was writing this article, I chanced upon the comprehensive waste recycling manual published by the *Bruhat Bengaluru Mahanagara Palike* (BBMP) that describes how to sort organic and plastic waste. While I cannot do much about the plastic that permeates my life, I can start by rinsing off my next milk packet or ice cream wrapper before throwing it in the dustbin, and carrying a trusty steel tumbler whenever I step out to the IISc canteen for my usual cup of chai.

Photo courtesy: Aditya Kabra, ZeroPlast Labs

The degradation of biocompostable plastics

Under the Night Sky

- Shreya Gangwal

Late hours on campus offer serene, vibrant vibes for students to unwind

Photo: Swapnankit Ramesh Bade

The IISc Main Building on a summer night

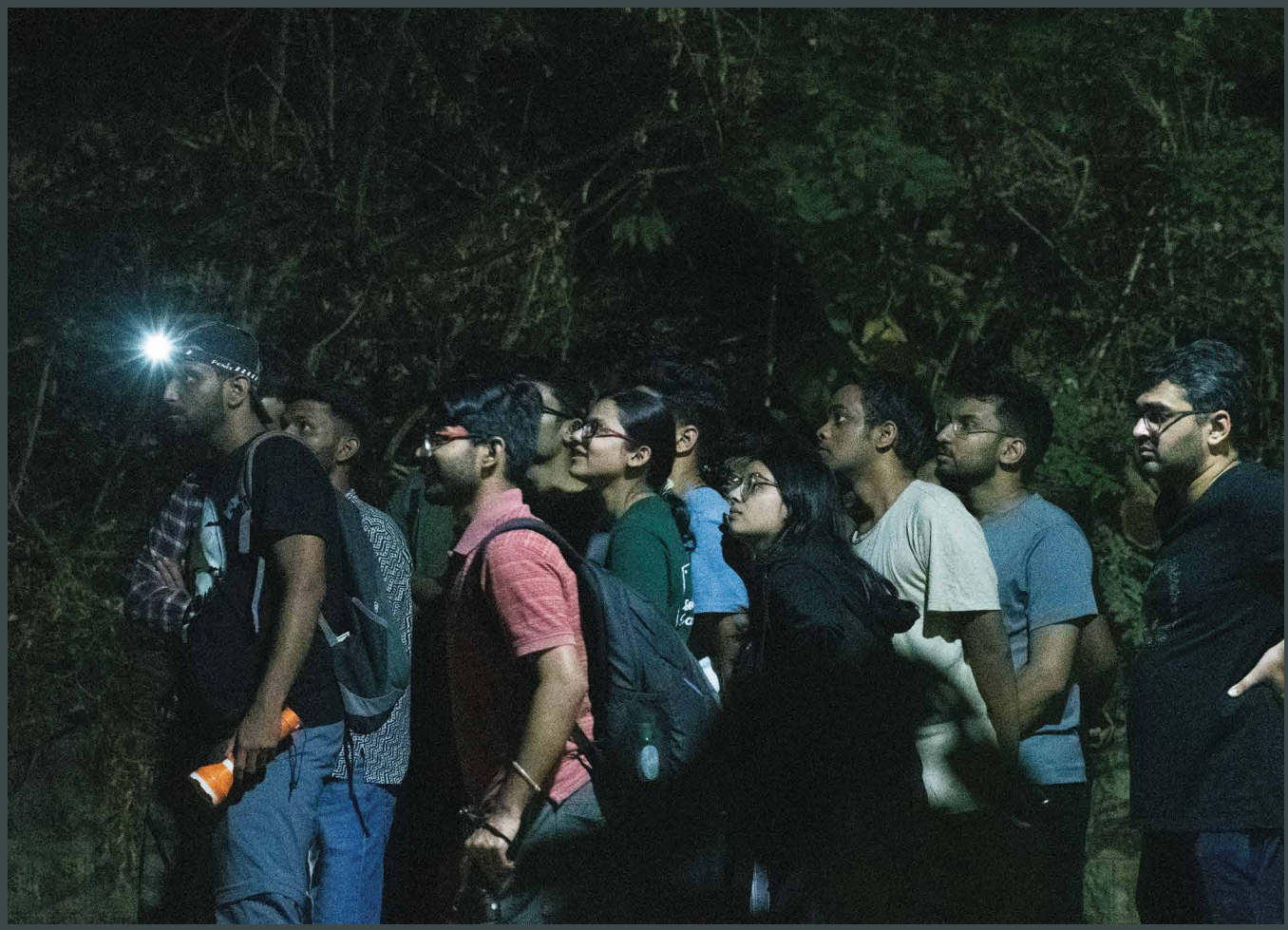


Photo: Abdus Shakur

Night walk members trying to spot a slender loris in the trees

The night was filled with the sounds of crickets chirping. Leaves crunched under my feet as I walked towards the nursery gates to meet up with members of IISc's Nature Club. We were going on a walk to see some of the nocturnal creatures on campus. Once the walk began, we switched on our torches and pointed them at the trees and ground, looking for signs of life.

Many students had joined the walk for the first time, like Surya Prakash, a Research Associate at the Centre for Neuroscience (CNS), who has always been fascinated by nature. Ekta, a UG student and member of Astrae, IISc's Astronomy club, likes to walk around campus listening to songs and watching the stars from building terraces. "But this [night walk] is something new that I am doing," she says.

Walking through the woods, we lifted a few large rocks and spotted some geckos running around underneath. One member noticed an insect inside a clump of dirt and called over Kedar Wagh, the convener and a PhD student under the Interdisciplinary Mathematical Sciences programme. Kedar identified it as the assassin bug – a venomous insect that kills other insects and wears their remains as a camouflage. We spotted many other fascinating insects, from colourful spiders to vibrant red bugs. Kedar, who has been exploring nocturnal wildlife for more than 13 years, and Pranav Datar, another club member and an MSc student at the Centre for Ecological Sciences (CES), often like to go around at late hours trying to spot snakes.

Soon we reached the road that leads to the back of the Department of Mathematics. Suddenly, we heard the long, shrill call of a slender loris up in the trees. It was exciting because spotting this shy animal up close is rare. All of us gathered close and started scanning the trees. When I moved my torch around, I saw a glint of light reflecting from what looked like the animal's eyes. But before many of us could get a good look, the animal escaped. However, before the night ended, we managed to spot another pair of these elusive mammals. I felt mesmerised looking at their large eyes peeking at me from the canopy. Just as the walk approached its end, we spotted a large poisonous toad hidden in the bushes, which we carefully sidestepped. The walk ended along the Mandhara Marg, near the Main Building of IISc.

> ***Before many of us could get a good look, the animal escaped***

Night walks are just one of many activities that students participate in past sundown. After twilight descends, and the din of dinner plates dies down, parts of the serene campus become abuzz with activity. Nighttime offers a much-needed respite for students who slog in their labs throughout the day. Walking around the campus at night gave me a chance to see the many different ways in which students spend and cherish these late hours.

Photo: Abdus Shakur

Poisonous toad spotted on Nature Club's night walk

For some students, the long, nearly empty roads are perfect for walks and bike rides. "The Gulmohar Marg is simply calm and cool, and I can cycle at full speed, and still hear the call of owls," says Abdus Shakur, a PhD student at CES. Some students, like Rahul Singh and his friends from the Department of Computer Science and Automation (CSA), like to borrow bikes from their friends and just ride around in the cool breeze. Shamsad Ali, a PhD student in the Department of Inorganic and Physical Chemistry (IPC), has named his bike 'Dhanno' in homage to the horse from the Bollywood classic *Sholay*. He likes to ride it alone on the empty roads when he can't fall asleep.

Along Mandhara Marg, there are always some people walking, jogging and exercising. One student I met says, "There's not a lot of people but it's not completely empty either. It's a good balance that I really like."

Walking down Mandhara Marg takes one to the century-old Main Building, an iconic spot that many night owls gravitate to. Students like sitting at the base of JN Tata's statue, to have relaxing conversations as they bask in the silent glow of lights from the building. "Every brick and archway showcases intricate charm and just sitting here looking at it makes me feel peaceful," one student says.

A little behind the statue is a plain platform hidden from sight and sound. I spotted a small group of friends enjoying the isolation in silence after a long day of work. Among them, Kain Dipendrasingh, a PhD student from the Department of Aerospace Engineering, likes to write poetry. The quiet nights of IISc provide him motivation for poems of solitude and peace, he says. The group spends many nights listening to songs and walking around the campus.

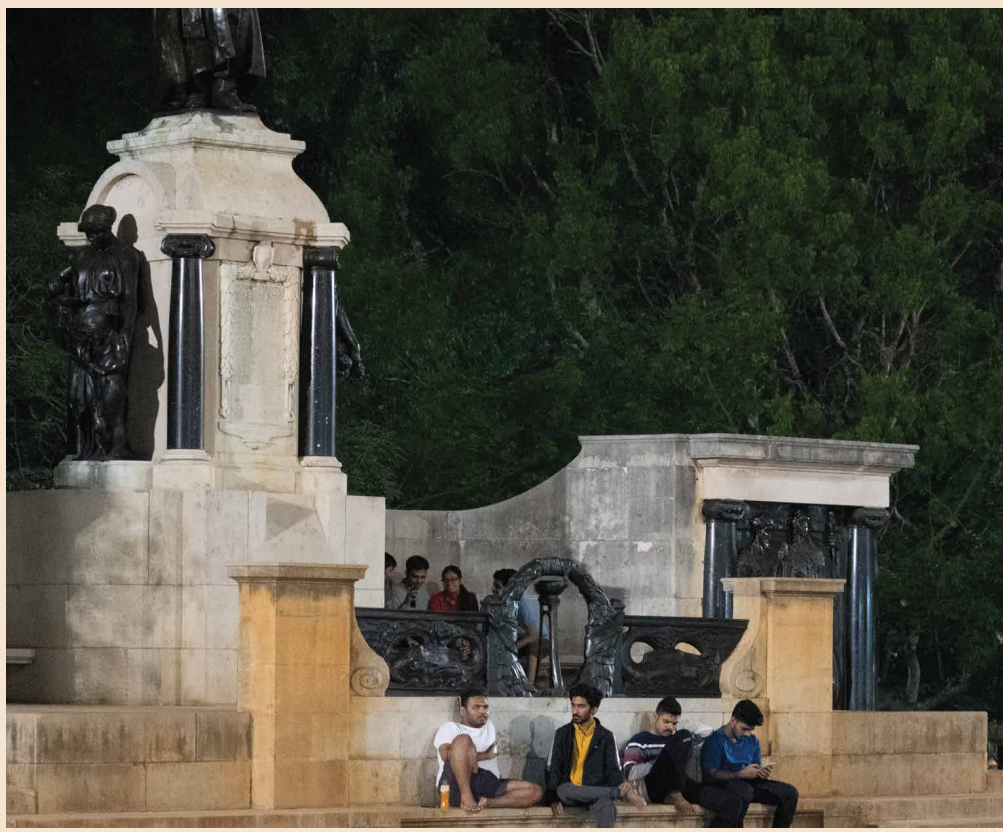
In the veranda of the Main Building, Samanwita Pal, a UG first-year student, sat with a laptop and some books spread around her. "Night time is the best time to study, and I like the open space here for studying," she says. Just in front of the JN Tata statue, three guys were drawing some lines in the sand. They were preparing for a game of Hopscotch while waiting for their friends to come and start a birthday celebration. "The birthday girl is yet to come, so we are just drawing the lines while we wait," Aviral Sood, one of the three and a UG student, says. Like countless IISc students before them, they plan to cut the birthday cake at the stroke of midnight against the captivating backdrop of the Main Building.

The Main Building is not the only place where festive birthday celebrations happen. As midnight approaches, the gazebos at the Sarvam complex also start filling up. Friends gather under the moonlit sky, cutting cakes adorned with candles and funny nicknames. Cake is smeared on faces, and laughter fills the air.

> ***As midnight approaches, the gazebos at the Sarvam complex start filling up. Friends gather under the moonlit sky, to cut birthday cakes***

Even when there are no birthdays, Sarvam is often filled with people either having tea with friends or enjoying a late-night dinner. Under the water tank, someone is usually playing the guitar as their friends sing along. For students like Subhashini Murugan, from IPC, having tea with friends at Sarvam at night is the best part of campus life.

Photo: Abdus Shakur



Students spending night hours near the JN Tata statue

Photo: Abdus Shakur

Students hanging out at the gazebo in Sarvam complex

She and her friends once stayed up till the early hours of the morning, having tea and planning a weekend trip. "IISc provides a lot of social space to mingle … It provides an atmosphere where even if you do not know people, you can go and talk to them," she says. Sougata Sarkar, a PhD student from the Astronomy and Astrophysics programme, says, "Hanging out with friends at Sarvam after a demanding workday is a complete stress buster." Her friend Jaydeep Mandal, a PhD student from the Department of Physics, says that they hang out at Sarvam after dinner every day, eating fruits and drinking juice.

Sarvam is also a venue for various night-time activities, like music and open-mic events. One night, there was even a discussion organised on mental health. Sushmita Dutta, a PhD student from the Department of Microbiology and Cell Biology (MCB), who attended the discussion, points out how students need spaces like Sarvam to improve their mental health and unwind. "[Earlier], there was no dedicated place where you could just gather and talk at night. It was a bit depressing at that time … but now, any time you come to Sarvam you can find a lot of people sitting around, and it is much better than it used to be," she says.

> ***Apart from hanging out at places like Sarvam, students also spend time playing games together to relieve stress***

Apart from hanging out at places like Sarvam, students also spend time playing games together to relieve stress. Vinod Jiani, a PhD student at the Center for Neuroscience, likes to play cards with his friends. He is a part of a large group of friends and the only time all of them can get together is at night. "Once in a while, we play cards, mainly Bluff and Uno … Cards are a good excuse to get together and talk while having some fun. And we love Bluff," he says. Most hostel lobbies have TT tables, foosball tables and carrom boards, and I almost always see them occupied even at night. The atmosphere is always cheerful and loud, with students hollering in excitement.

When exam season approaches, the TT tables in the New Girls Hostel lobby gain a second purpose. Students gather around them late at night, to discuss and study together, something that is difficult to do in the quiet library. "For collaborative discussions, it is best to have a common area like this," Kevin Mahesh, an MTech student at the Department of Computational and Data Sciences, says. Even when exams are not there, students engage in impromptu study sessions and lively debates over tea, illuminated by the soft glow of laptops.

Many students also need to stay back in labs at night – some experiments require 24-hour observations, resulting in students staying up all night in departments like CeNSE and DBG.

One of the departments that is often busy through the night is the Department of Design and Manufacturing. Students here take part in brainstorming sessions in the night that sometimes go on until the wee hours of the morning. Hemanth GN, an MDes student, explains that these sessions need to happen in groups, and everybody becomes free only during the night. "Our department is multi-disciplinary ... So, from all the streams, ideas will be dumped on the table and we will see which is feasible. There are some 14-15 steps we will have to follow and then we'll come up with a design," he explains.

Sometimes these discussions go on till 7.30 in the morning after the sun has risen and birds have started their morning clamour. The students need to squeeze in some quick shuteye, and then rush to their classes and labs. They will have to spend another long day filled with research and studies before they can return to the leisure and freedom that the night offers.

Shreya Gangwal is a PhD student in the Centre for Ecological Sciences, IISc and a science writing intern at the Office of Communications

‘In this field, every day is a new experience’

- Abinaya Kalyanasundaram

Photo courtesy: Parveen Kaswan

Parveen Kaswan feeding bananas to a rescued orphaned elephant named Gajraj in Jaldapara

Parveen Kaswan is an officer in the Indian Forest Service, currently posted in Jaldapara National Park in West Bengal, home to one of the largest remaining populations of the Indian rhino (also called the greater one-horned rhino). Born in Mirjawali village, in the Hanumangarh district of Rajasthan, his journey to this position was circuitous.

He pursued a BTech in Aerospace, Aeronautical, and Astronautical/Space Engineering from Amity University, followed by an MDes from IISc in 2012. After IISc, he nurtured a desire to work in the civil services. He passed the UPSC exam for IFS as a 2016 batch officer, as part of the West Bengal cadre, and then completed a two-year Master's in Forestry at the Forest Research Institute, Dehradun. He has traversed diverse terrains, patrolling deep into the forests of West Bengal, walking along rivers, restoring grasslands, tracking animals and poachers. Years of observing animals in the wild led him and collaborators to discover an interesting elephant behaviour – the burial of their dead. Beyond his responsibilities, his informative and picturesque posts on social media about India's wilderness have gained him a loyal and growing fan following.

After returning from an intensive anti-poaching camp in the field, Parveen Kaswan speaks to* CONNECT *from his office in Jaldapara, sharing glimpses into his life behind the job of protecting the country's forests. The interview is edited for clarity and flow.

Tell us about your current posting. It is a beautiful place.

Yes, Jaldapara National Park is a rhino landscape. There are very few places where you will find rhinos in India, and Jaldapara is home to the second biggest population of the one-horned rhino, after Kaziranga National Park. Before this, I was in the Buxa Tiger Reserve for three years.

You just recently returned from an anti-poaching camp as well, right?

Working with the IFS, there are many things we need to look after. One of them is anti-poaching activities. Both Buxa and Jaldapara are near the borders of China, Bhutan, and Bangladesh, and are thereafter connected to northeast and southeast Asia. They are very vulnerable to poaching and illegal activities. There are many anti-poaching camps in both Buxa and Jaldapara which are manned 24x7. And it is my job to ensure that they are well maintained and equipped. So, I keep visiting these camps.

What kind of technology do you use at these camps?

We have basic technology like GPS trackers that we use to know which areas are being covered [patrolled] by the teams. When I was in Buxa, we used a special app called M-Stripes, which is applicable across India. It records their [range officers'] presence, movement pattern and can even record the presence of animals, for surveys and scientific purposes. In Jaldapara, we also use GPS for elephant monitoring and patrolling. Every month, we sit with our teams, see what kind of patrolling they have done, what are the vulnerable areas covered, and so on. We also use drones for mapping or monitoring.

I read a recent news report about the infamous rhino poacher Rikoch Narjari being apprehended in Assam. This seems to be a key part of your work too?

Yes. Recently, we also had a case of pangolin smuggling. The smuggler was convicted and sentenced to five years in jail. In another case, a clouded leopard's skin was seized from a poacher and a three-year jail term was given to him and his accomplice. And recently, in a hornbill hunting case, a three-year jail term was given to a person.

Our teams investigate [these incidents], attend the trial(s), and present our cases at the court. If everything goes well, we get convictions.

I'm curious, gathering evidence, getting convictions … are these difficult?

Yes. Convictions in India are at a very low rate, in all kinds of cases.

Photo courtesy: Parveen Kaswan

A rescued Himalayan griffon vulture being released back into Buxa Tiger Reserve

As a precaution, we monitor and track people who are habitual offenders, with a history of poaching or illegal activities. Right now, only if we find [suspect] something, we will seize or arrest somebody. That will not solve our problem. It will be solved when there is preventive enforcement, that is, if we can avoid poaching. There are challenges, but at the same time, there are opportunities for learning.

What's an average day in your work like?

As a park manager, activities keep happening in the park that I need to keep track of. There is habitat management; we create grasslands and maintain old grasslands so that animals have enough food and do not move out. We do a lot of work to reduce human-animal conflict because animals like rhinos, bison and sambar deer will keep moving outside the forest. If any conflict happens, we figure out how to calm everybody, coordinating with other departments. The police and district administration are very helpful.

Then there is establishment work. In Jaldapara National Park, I have 15 ranges manned by officers – there are beat officers and forest guards so whom to post where … all of that. It is all about people management, getting the most out of people, and working as a team. Then there is infrastructure management of a park, say, bridges or anti-poaching camps. I have 22 anti-poaching camps inside the forest in Jaldapara.

One of the important jobs of a park manager is to manage tourism. With a huge number of vehicles, people want to see something and they need good experiences. In the end, if people don't know what is being conserved, and why, they will not help conserve. So, tourism management is an important factor.

Last year, there were one lakh plus footfalls in Jaldapara. With that much footfall in Jaldapara, you can understand what tourism brings to these nearby places. From safari owners to hotels and homestays to guides, it provides opportunities for a lot of people on the fringes of the national park to generate livelihood.

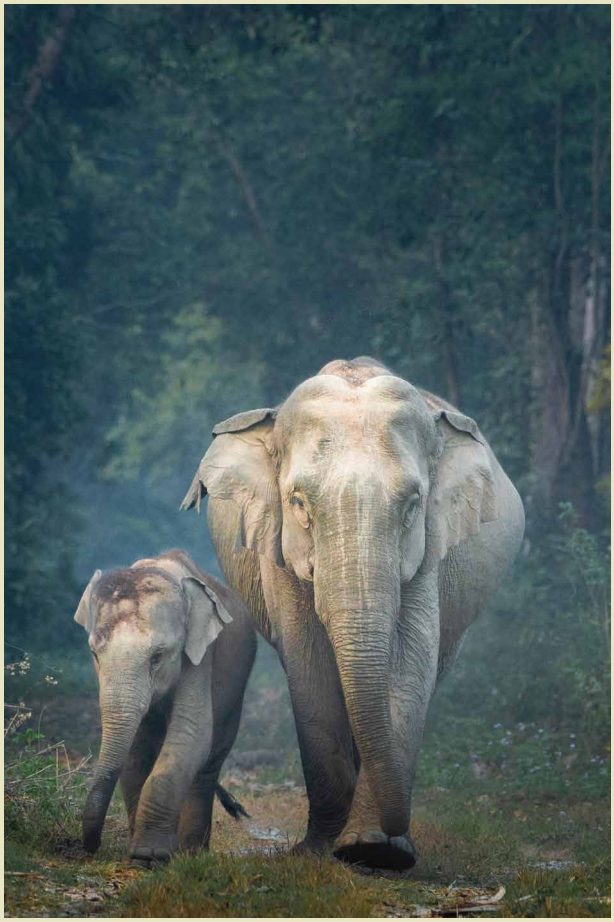


Photo courtesy: Parveen Kaswan

Elephant mother and calf in Buxa Tiger Reserve, West Bengal

I'm sure there are plenty of rewarding moments. Were you posted in Buxa when a tiger was spotted there in 2021, after almost two decades?

Yes (*smiles*). We documented it in December 2021. I was there.

That must have been a huge event!

Exactly. Buxa once had a lot of tigers. I don't know the exact reason, there may be many, but the tigers left [two decades ago]. So in 2021, it was a "Eureka" moment when we documented one tiger and then another one in December 2023. Now I hope the tigers will move back. The prey base and protection are improving.

How is the tiger population in Jaldapara?

We do have some movement of tigers, but Jaldapara National Park focuses mainly on the Indian one-horned rhino. Now we have more than 300 rhinos in Jaldapara. There are also leopards, bison, sambar, hog deer, spotted deer, and other animals.

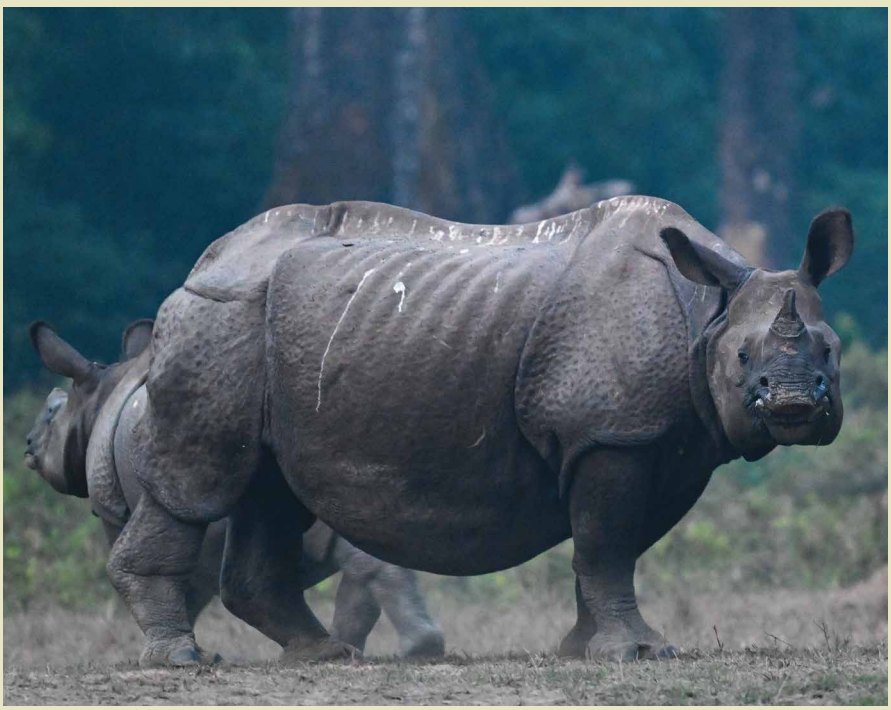


Photo courtesy: Parveen Kaswan

An Indian one-horned rhino in Jaldapara National Park, West Bengal

Going back in time, you studied astrophysics and design. How do the learnings from these fields shape your current work?

It made me [more] analytical. I can give hours to a job, I don't get bored. I love to work. So this is, I think, the change that these fields have brought for me.

How do you remember your days at IISc? What are your favourite memories from your time here?

I had a very good experience at IISc. I made really good friends and it is a very beautiful campus. My centre [CPDM] was near Prakriti, where we had most of the meals, from breakfast to evening tea.

> ***An important job of a park manager is to manage tourism … if people don't know what is being conserved, they will not help conserve it***

I think IISc will always remain in my heart. It improved my personality. I come from a very small village, in the Mandya district of Rajasthan. Nobody ever went to other places in my family; they are still farmers. So, I had very little exposure. Nobody was there to guide me. I prepared for GATE and then I went to IISc. In my department, every Thursday, there would be a presentation, and this improved my way of talking and presenting. And communication is an important skill that needs to be acquired. Since I was not able to acquire it from my parents or my small school, IISc helped a lot in that.

That's wonderful. Coming back to the present, I wanted to ask you about your recent paper. People have known that elephants are social animals but the finding you published – that they grieve and bury their dead – is intriguing. What set you off to look into this?

I have been working in the forest for a few years now, and I have always been curious about elephants. I read about them in old journals and books, and kept monitoring their movement when I was in Midnapore, in Bankura district (West Bengal), which sees seasonal migration of elephants from Jharkhand, Odisha, and other places. So, I kept tracking those elephant groups, how they behave, celebrate, and mourn. I have written some 100 pages of notes about their movement and behaviour, just for my understanding. I always thought that if they are known to celebrate birth, they would mourn also.

When I came to Buxa, around 2022, I observed an interesting case in a tea garden, where an elephant calf was buried. And it looked like it was [done] by an elephant herd; we observed many elephant footprints in the mud, from small to big. Maybe, we can assume, it [the dead calf] fell into that ditch by accident and then the community [the herd], all of them participated in the burial.

But then, when I started observing, I realised that there were more such cases; we came up with five. It was a trend; it cannot be an accident. So in this paper, we have studied peri-mortem strategy, post-mortem behaviour, and marks on their bodies. We are presenting five such cases in which we realise that there is a community burial every year in Buxa.

> ***In 2021, it was a "Eureka" moment when we documented one tiger in Buxa Tiger Reserve after almost 23 years***

Our paper is not final, it is very open-ended. Maybe after three or four years, I will document a few more such cases.

Photo courtesy: Parveen Kaswan

Parveen speaking at a meeting of a village committee in Buxa

Many people look at wildlife as something "separate" from humans. Do you think such studies help change such thinking?

We are not humanising elephants. What we are saying is that every species has its own specific needs, cultures or behaviours. And this is how elephants behave; they mourn and do community burials. They also create a milestone. This is a sign of a highly intelligent animal.

In the five cases we observed in our paper, we realised that they [the herd] are not coming back to that [burial site]. They have reduced their migration to that part. There can be many reasons. One may be because they have already buried it. Or else, maybe they know that the bodies have already been removed by humans. That is also possible.

In many cases, in Africa or other places, there is documentation where elephants came back to see [the burial site] at different stages of disposal of a body. In all cases, they were not buried by the elephant families. There are also papers on African elephants where it has been observed that they [elephants] put leaves on it [the grave] or then put sand over it. Maybe because they are not finding proper places, like ditches. Because elephants can't dig holes. Maybe it is opportunistic.

Do you think the impetus for wildlife conservation in India is short-lived? For instance, the incident in Kerala with an elephant and firecracker became a huge issue, and many were invested, but public interest died out soon. How can we retain this involvement consistently?

One of the ways, I found, is to involve a lot of people in the decision-making process for conservation. These days, thanks to technology like camera traps, GPS, and so on, we know what kind of animals are around and what spaces they are occupying. It is important how we present these findings to people, it should be in a manner in which a normal person is able to consume.

As they often say, catch them young … Maybe in schools and colleges, these kinds of steps should be taken.

Of late there seems to be more interest in creating films and TV series about wildlife conservation, like *Poacher* and *Sherni*.

I started watching *Poachers*. People like us will connect with such a series, but I want [more] people to connect with it. With more such series, I hope the message will spread wider.

I mean, I am at a sufficiently high rank, so I am visible to people. I want my frontline staff to be visible – what they are doing, how they are doing it, what difficulties they face, how the terrains are. It is a thankless job. Only if people know what we are doing will they appreciate it. There should be more outreach.

> ***My work keeps me healthy. Sometimes we walk 10-12 km in a day***

I feel like *Poacher* did a nuanced job of showing the challenges that frontline staff face, including threats to life. How do you navigate such things?

I believe in teamwork. Wherever I go, I connect with my field staff. If I can help them personally or in any way, I try to. I try to motivate them. Because unless you go to the field, they will not feel connected. Motivation is the key.

You also post a lot of beautiful pictures on social media.

I rarely post about any other thing except forest and wildlife. Since I have this opportunity to have a good following, I keep sharing information about wildlife or the natural world with people. A lot of people don't know much about what we do, how it is done, about wildlife or about their habitat, or their protection status. So there is curiosity.

Any memorable experiences you cherish?

Yes, the beautiful thing about this field is, every day is a new experience. A beautiful moment that I remember is when we documented that tiger in Buxa after almost 23 years. Another is that for many years, we tried to relocate one village from the core of Buxa Tiger Reserve, and we were able to. It took us two and a half years, from funding to dismantling to moving out. 191 families were relocated from the forest and shifted outside.

Your work seems to involve a lot of travelling and walking. Is that hard?

Actually, it keeps me healthy (*laughs*). Sometimes we walk 10-12 km in a day. I love to go to the field, to eat at camp, and stay in my camp offices. It is not stressful for me. I enjoy it.

Photo courtesy: Parveen Kaswan

Parveen Kaswan indulges in photography during his field work

Behind the beams

- Sindhu M

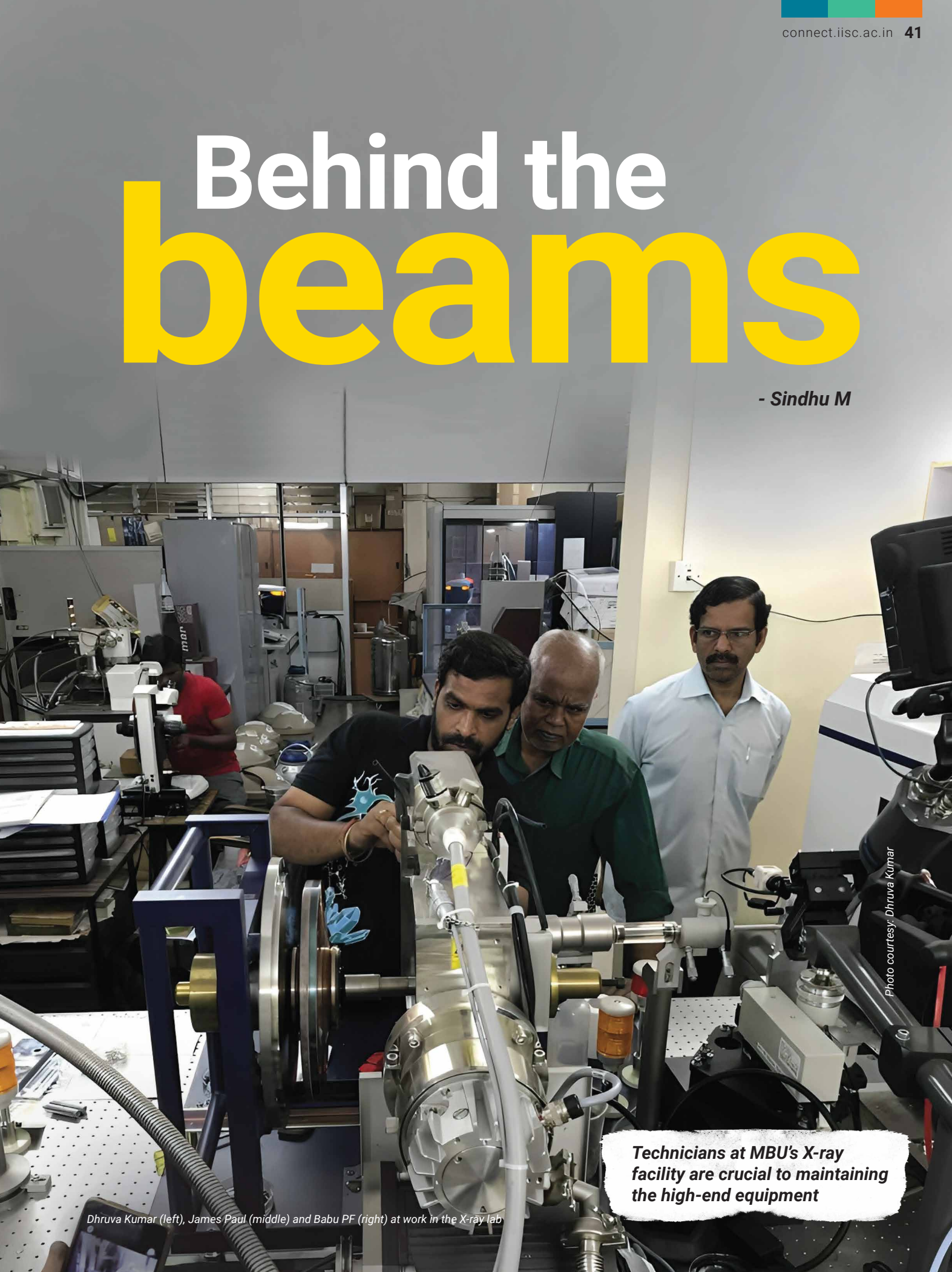


Photo courtesy: Dhruva Kumar

Technicians at MBU's X-ray facility are crucial to maintaining the high-end equipment

Dhruva Kumar (left), James Paul (middle) and Babu PF (right) at work in the X-ray lab

On pushing open the yellow door marked with a bright radiation hazard sign, a wave of cool air belched out by 20 year-old air conditioners greets you. You can hear the low-pitched hum of compressors and generators, also 20 year-old occupants of the X-ray lab at the Molecular Biophysics Unit (MBU), IISc.

Just as Superman's vision can see through objects, X-ray beams help scientists decode the architecture of nano-sized proteins and other macromolecules. X-rays are used to study protein structure because the wavelength of X-rays is smaller than protein size. The X-ray lab at MBU is a national facility established in the 1980s largely due to the efforts of Mamannamana Vijayan, late professor in the department. The herculean task of maintaining the X-ray machines – worth tens of crores of rupees and requiring continuous cooling and uninterrupted power supply – falls on the shoulders of full-time technicians. Currently, the technicians who work at the lab are Babu PF and Dhruva Kumar.

Dhruva, a former mechanic with an intuitive grasp of machinery, joined the lab in 2011 and is in charge of hardware. Babu, with a background in physics, manages software and assists users with crystal mounting and data collection. Their roles seamlessly blend, with one readily covering for the other. Their personalities also complement each other – Babu's introversion is balanced by Dhruva's outgoing nature. Dhruva even brings his seven-year-old son to the lab after school hours, lightening the mood in the lab.

Their knowledge about the facility was passed on by James Paul, a former technician, who has now retired. "James was like an elder brother to us," says Dhruva. James spent his early career as a grease-stained auto mechanic. His years of taking apart and rebuilding engines made him adept at figuring out how machines work, although his formal education ended at class four. This skill caught Vijayan's eye, who urged James to join the X-ray lab. Before James, the first technician at the X-ray lab was C Govindaswamy who went abroad to get trained on using the machine. In his autobiography, *A life among men, women and molecules*, Vijayan writes: "Technical support, initially of C Govindaswamy and later James Paul, was very important [in setting up the X-ray lab]. The other technical personnel who helped were Dhruva and Babu. In fact, we all worked as a team."

The stuff that proteins are made of

To produce X-rays, electrons are first generated by heating a filament placed in a vacuum chamber. It is essential that there is an adequate supply of chillers to cool down the instrument and that vacuum is always maintained in the machine. To ensure this even during power cuts, the technicians check the power backup regularly and see if there is enough diesel in the generator. They also have to periodically refill liquid nitrogen to guarantee adequate chiller supply.

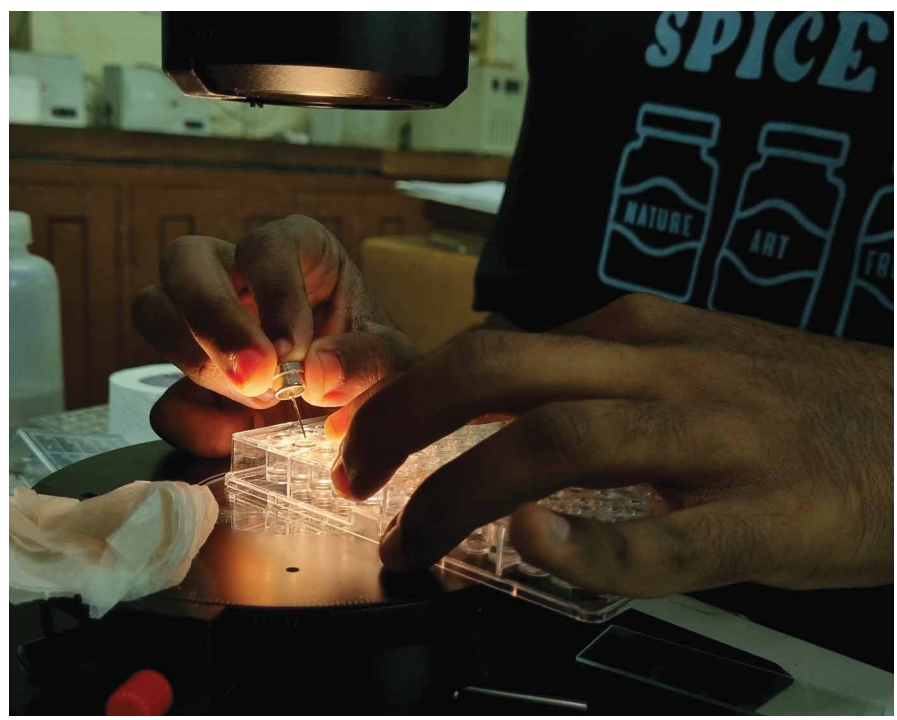
Once the electrons are generated from the filament, they need to be accelerated using a high voltage. Electrons zipping through the vacuum chamber slam into the anode filament, producing X-rays. The technicians have to replace the filament and align the X-ray beam to hit the protein crystal periodically.

To look at protein crystals, researchers carefully manoeuvre a loop smaller than a millimetre to pick and mount the crystals in the machine. However, the high energy of the X-ray beam may disintegrate the crystal. To avoid this, the crystals are cooled with liquid nitrogen; some crystals may require a cryoprotectant. Then, they are bombarded with the X-rays, which causes the crystals to diffract the rays in different directions. The diffraction pattern is collected on an image plate made of photostimulable phosphor and analysed to determine the 3D structure of proteins.

> ***Keeping vital components functional at all times is primarily Dhruva's role. Babu's forte is assisting users with mounting the crystal, data collection, and data processing***

Keeping these vital components – generators, compressors, and AC units – functional at all times is primarily Dhruva's role. Babu's forte is assisting users with mounting the crystal, data collection, and data processing. "Babu sir taught me the working of the X-ray machine and made sure I understood everything, without stopping at just helping me mount the crystal. He is very patient and repeats himself two or three times to help me understand," says Sankar Mahesh, a PhD student in the lab of Balasubramanian Gopal, Professor at MBU and faculty in charge of the X-ray lab.

Photo: Sindhu M



A researcher carefully picks up a crystal using a loop under the microscope

"On some days, the X-ray lab runs smoothly, but on some days, all hell breaks loose," says Gopal. During August 2023, there was a power cut at MBU. The UPS power supply to the X-ray lab was accidentally cut off, and the machines were abruptly turned off. Dhruva had to rush in early in the morning, check the power sources and generators, and restore the power supply. Each machine was then checked, and after days of effort, the vacuum was restored, and the machines restarted.

Four decades at IISc

Babu has been associated with the X-ray facility for over two decades, and with IISc for 37 years. "My designation has changed many times over the years – from helper to junior research assistant to project assistant to project associate, and most recently consultant," he says. With a Bachelor's degree in physics, he first joined IISc in 1987 as a helper at the Sophisticated Instrument Facility at the Department of Physics (the facility later became the NMR Research Centre). When the faculty member under whom he had worked took a sabbatical, Babu's project was terminated and he had to look for a new job. He then joined the lab of KP Gopinath, former chair of the Department of Microbiology and Cell Biology as a lab assistant. "A lot of things were new to me in a biology lab, coming from a physics background. I learnt a lot of biology during this period, and it has helped me since," says Babu. In 1992, he made a request to Vijayan, and joined the X-ray lab.

Over the years, Babu has witnessed generations of X-ray crystallography equipment and researchers. "When I joined the facility, Professor Gopal was a PhD student with Professor MRN Murthy. I am now working with students of students!"

> ***Babu has been associated with the X-ray facility for over two decades, and with IISc for 37 years***

The equipment themselves were difficult to handle in the early years of the X-ray lab, he adds. A critical step in X-ray crystallography is to orient the fine X-ray beam, with a diameter as small as 0.6 mm, to hit the crystal accurately. "I vividly remember my first experience of aligning the X-ray beam with MRN Murthy and his students," Babu reminisces. Moving the X-ray beam is now mechanised, and aligning it only takes about half a day, compared to about a week earlier. Even computers were a rare sight in those days. "Students used big cassette tapes to store data, and data transfer itself would take days. These days, it only takes a tiny pendrive and a few minutes," chuckles Babu.

A love for learning

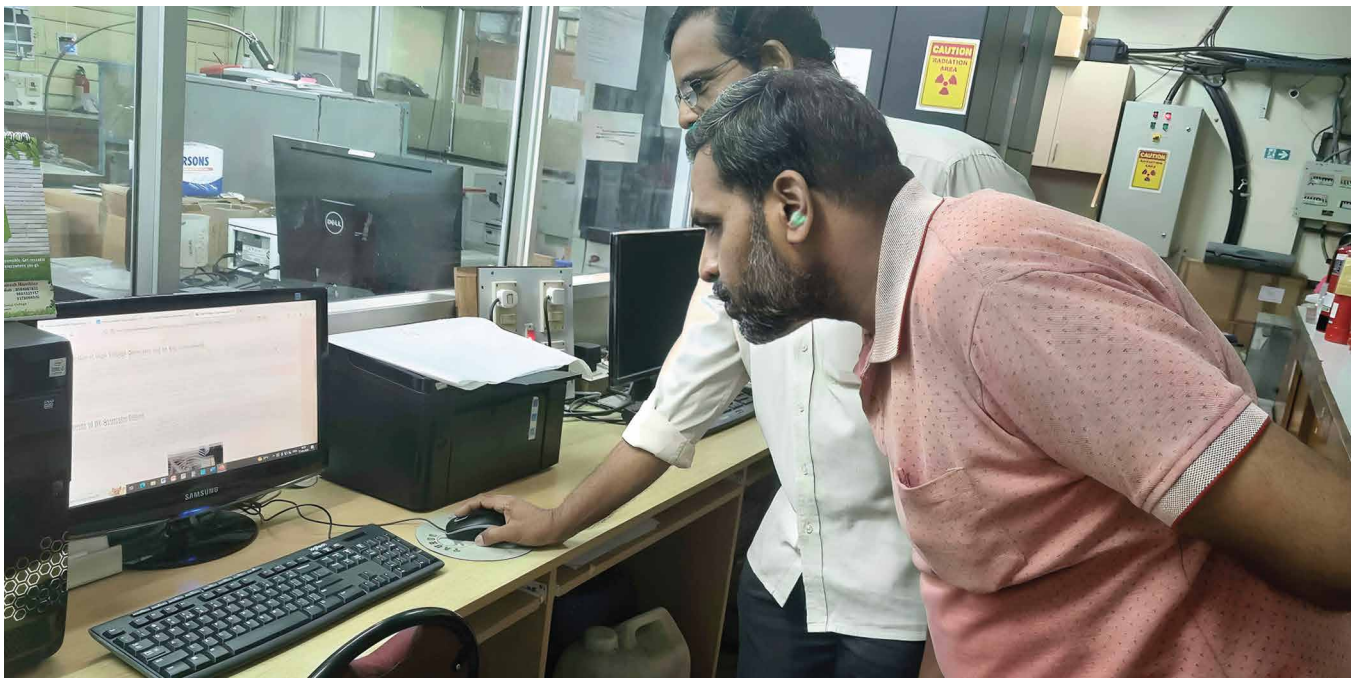
Unlike students, the technicians do not have the chance to take up formal courses in X-ray crystallography. A lot of their expertise is therefore self-taught. Dhruva has decoded the mechanics of the machine by merely looking at its different parts and connections. "My favourite part about this job is the hands-on touch I get with the machines," he says, smiling.

Sometimes, their understanding of the machine's working is more in-depth than the instruction manual that comes with the equipment. They need this skill if the machines malfunction because it usually takes a few weeks for representatives from the manufacturing companies – typically based in Japan or Germany – to turn up. The cost of fixing it can also add up to a few lakh rupees. In such cases, the technicians try to fix the machines by themselves. Sometimes, they use spare parts from old machines of the same make to fix the problem. Recently, there was a software issue with one of the machines. The operating system used for the connected equipment is Windows 7, and there were issues with updating it. The vendor said that it would cost lakhs to supply updated software. But Babu was able to fix the issue by identifying a missing library and retrieving it from a previous backup.

Photo: Sindhu M

Old mechanised X-ray machines at the X-ray lab

Photo: Sindhu M



Babu and Dhruva in the X-ray lab at MBU

"Initially, I used to hesitate even to mount crystals of students because I know how difficult it is to obtain protein crystals. Over time, I have become more confident, and I routinely help students with picking and mounting crystals," says Babu. Now, he is able to crystallise proteins and solve their structures on his own for consultancy projects with industries. He has solved the structure of over 50 variants of insulin by himself. "Anytime you enter the X-ray lab, you can find Babu sir reading a protein structure paper," says Ankur Singh, a PhD student in Gopal's lab.

> ***"My favourite part about this job is the hands-on touch I get with the machines," Dhruva says***

"He suggests when to use a cryoprotectant for the crystal based on his experience. He also helps me with analysing the diffraction pattern to distinguish biomolecule crystals from salt crystals," adds Sankar. In fact, Babu points out, newly joined X-ray machine company representatives visit IISc to learn from their experience.

Decades of routine work has not diminished Babu and Dhruva's desire to keep learning. "RNA crystallography is new to our lab, and Babu sir eagerly asks me about it," says Sankar. Babu also takes help from the students in the lab when he encounters a new protein structure, or in making protein structure infographics. "Students initially learn from the technicians, and then technicians learn from the students," says Gopal. Sankar adds, "They are very kind. It feels nice to work with kind people around me."

Crystal clear commitment

The technicians' commitment extends far beyond their job descriptions. "They treat the X-ray lab as their own. They are ready to come to the lab even during holidays, when students themselves may hesitate," says Ankur. Dhruva is a common sight even during the weekends, checking the generators and refilling diesel. He is immediately available in case of power cuts or other emergencies at any time of the day and leaves only after the lights come back on.

Once, there was a short circuit and a spark just outside the X-ray lab late in the night. Dhruva came in well after 11 pm and made sure that the X-ray lab was fine. Dhruva also helps the students in setting up the microscope for Open Day demos.

Even during COVID-19, they worked continuously to refill diesel and liquid nitrogen and keep the X-ray lab in order. They also came to the lab frequently and assisted students, who were only allowed in during specific time slots, to complete their experiments.

Although Babu has been working with IISc for 37 years now, he still does not have a permanent position. With hopes of securing a permanent position, he tried to complete a distance PG diploma course in Physics from Annamalai University. But it was very challenging with a full time job that offered no vacation benefits, and he had to abandon his attempt. He still managed to finish a Master's in Computer Application (MCA), and it has helped him a lot in his job, he says. By the time permanent positions were advertised at IISc, however, he had crossed the prescribed age limit and could not apply for them.

With the X-ray lab becoming a second home for Babu and Dhruva, they are part of every celebration – birthday parties, lab outings, farewell dinners. They have developed a special bond with all the students who have passed through the lab, many of whom continue to stay in touch with them.

"It is very satisfying for us when old students come back and visit us after getting a faculty position," says Babu, beaming.

Sindhu M is a PhD student in the Department of Bioengineering, IISc and a former science writing intern at the Office of Communications

'My time at IISc allowed me to forge enduring friendships'

- Kavitha Harish

Photo courtesy: Ranganayaki

Moving from serene Coorg to bustling Bangalore, Ranganayaki Mallur Krishnaswamy forged a career path unusual for women in her time. Born to a renowned veterinary doctor in Coorg in 1948, she finished her schooling in Pollibetta Taluk and later completed a Pre-University Course (PUC) in the small town of Virajpet, Karnataka. Despite the challenges of pursuing education in this remote region, she aspired to work in civil engineering. She then pursued a Diploma in Civil Engineering Draughtsmanship at the Government Women's Polytechnic College in Bangalore, carving a niche for herself in the once male-dominated field. She joined IISc in 1976 as a draughtswoman in the Department of Civil Engineering, where she worked for 27 years. Now 75, she speaks to CONNECT *about her career, memories of family, and life after retirement.*

It is wonderful that you spent your childhood in Coorg. Tell us more about it.

My father was a dedicated veterinary doctor with the forest department, specialising in treating elephants in Coorg. In those days, there was a method to capture elephants called 'khedda' that would cause grievous injuries to some elephants. My father tended to these magnificent animals, nursing them back to health. I recall those early experiences with awe and fondness. This was the time my fascination with the natural world and its inhabitants began to take root.

A strong memory I have of my father is from 1958 when he received a special invitation to visit the Taronga Zoo in Sydney, Australia. The Indian Government had gifted an elephant calf from Coorg to the Zoo, and my father, accompanied by one mahout, embarked on a journey by ship to take this creature to its new home.

When my son, Tejas, visited Sydney a few years ago, he mentioned that the zoo's archives still preserve some photos from that time, of my father, the ship, the lorry transporting the elephant, and even the first encounter between an Australian woman and the adorable calf.

After your diploma in civil engineering, how did you begin your career?

I worked for over six years at Chandavarkar and Thacker, an architecture firm in Bangalore. I had responded to an advertisement for a draughtsman position. Unfortunately, it was not referred to as a draughts*woman* (*laughs*). Following an interview and a meticulous drafting test, I was fortunate enough to be offered the job.

> ***'I had responded to an advertisement for a draughtsman position. Unfortunately, it was not referred to as draughtswoman'***

When did you think of joining IISc?

IISc was not unfamiliar to me. My late cousin, Shashikala Krishnswamy, worked in the Molecular Biophysics Unit. I was aware of IISc's reputation as a premier institution for research and higher education, and so I felt drawn to being part of such a community.

In January 1976, I stepped into the world of IISc. Little did I know that this journey would span almost three decades, giving me invaluable experiences and opportunities for growth.

After joining the Department of Civil Engineering, I found myself as the sole woman staff member. I formed connections with other women students within our department, creating a supportive network. I also developed a close friendship with the late Rajeswari Chatterjee, a professor and later chairperson of the Department of Electrical Communication Engineering (ECE).

Tell us more about your bond with Rajeswari Chatterjee.

I had the privilege of having a close association with her during her tenure. She held the distinction of being the first woman engineer to be appointed on the faculty of IISc. After her retirement, I collaborated with her on several illustrations for a few books that she authored.

I often accompanied Rajeswari to various places; she enjoyed conversing with me, and I was her constant companion (chuckles). Our journeys together included visits to many friends in and around Bangalore, as she had a keen interest like me in literature, including works by SL Bhyrappa.

One particularly memorable experience was when she invited me to accompany her to a conference at Cochin University that lasted for eight days. At the time, there was a railway and airline strike, prompting us to go on a road trip to Cochin. The university had arranged comfortable accommodations, and while she attended the conference, she encouraged me to explore the city.

> ***'After joining the Department of Civil Engineering, I found myself as the sole woman staff member'***

How did you like your work at IISc?

I started my professional journey in the Department of Civil Engineering, dedicating two decades to the field. In

Photo courtesy: Ranganayaki

Ranganayaki (left) with the late Rajeswari Chatterjee (centre) and a friend at a womens' conference (circa 1992)

Photo courtesy: Ranganayaki

Ranganayaki in the CPDM office (circa 1998) with her colleague Elizabeth

1995, I transitioned to the Central Workshop, later rebranded as the Centre for Product Design and Manufacturing or CPDM (now it is the Department of Design and Manufacturing). My role as a draughtswoman was central to the preparation of figures, machine drawings, and plans for building components in an era before the prevalence of tools like MS Excel and AutoCAD.

In those days, hand-drawing figures and preparing visuals for presentations were an integral part of academic life. I also assisted professors during consultations, contributing to reinforcement detail drawings and other civil engineering sketches crucial for on-site execution.

I had to balance the demands of raising two children alongside my professional responsibilities. After five years of joining IISc, I achieved a significant milestone as one of the first supporting staff members to pass a promotional exam conducted by IISc. However, despite subsequent promotions, my job role and title remained constant until my retirement.

My time at IISc allowed me to forge enduring friendships, and witness colleagues from the department complete PhDs and some of them even returned as professors. Transitioning to CPDM, I had the privilege of attending classes with the inaugural batch of MDes students, creating cherished memories.

Did you have any additional responsibilities other than draughtswoman work?

I had several administrative duties, such as managing the library at the Department of Civil Engineering, where I ensured the organisation and accessibility of resources for students and faculty.

I also helped create an annual calendar. This involved designing and producing the calendars that became essential fixtures under the glass sheets on individual desks. I also actively helped my colleagues during busy times – particularly during interviews and conferences – coordinating schedules, managing logistics, and providing general assistance.

How has the Institute changed during your tenure?

IISc has always shown a commitment to excellence in research and education. The collaborative environment and the constant pursuit of knowledge made my years both fulfilling and enriching. From the precision of drafting to the intricate details of various projects, each day presented new challenges and learning experiences.

Over the years, I also had the opportunity to see several dignitaries, including Prince Charles, JRD Tata, Rajiv Gandhi, and APJ Abdul Kalam, during their visits to the Institute. I recall attending notable events, including the opening of the JN Tata Auditorium; JRD Tata's inspiring speech at the event left a lasting impact on me. I also feel great about serving the Institute during Satish Dhawan's tenure as the director.

> ***'In those days, hand-drawing figures and preparing visuals for presentations were integral tasks'***

Students, faculty, and staff – we were all quite close and we celebrated various milestones together. From monthly outings on paydays to celebrating thesis submissions and colleagues' weddings, these shared moments added a special charm to our professional lives. March 2003 marked the end of this chapter, but the memories and the impact of those 27 years remain etched in my mind.

How do you feel about the IISc campus now?

After visiting the campus recently this year, I was heartened to see that it has changed a lot. Earlier, women faculty and staff were scarce, but now there's a thriving community of female

Photo courtesy: Ranganayaki

Ranganayaki receiving a memento during her voluntary retirement in 2003 from the then Registrar of the Institute

academics and students. This reflects a positive evolution towards inclusivity and gender diversity within the academic setting.

However, I also noticed there has been an increase in new buildings, and diminishing of greenery, giving way to a more urbanised environment. The increased prevalence of two-wheelers on the streets has also rendered the campus less pedestrian-friendly, particularly for senior citizens. I hope that the Institute prioritises restoring a pedestrian-friendly and serene atmosphere.

What was the reason for you to go on voluntary retirement?

The emergence of computers rendered the role of a draughtswoman obsolete, and I found myself at a crossroads. To adapt, I tried to join this new technology wave by participating in the labs of the newly introduced Master of Design (MDes) programme. But my lack of training in sophisticated tools and software, such as AutoCAD, hindered my transition to these contemporary practices.

> ***'The emergence of computers rendered the role of a draughtsman obsolete'***

Unfortunately, I struggled to align my expertise with the rapidly changing professional environment, even though I tried to acquire new skills in order to stay relevant. I had to make a difficult decision. With about six years of service left behind at the institute, I chose to retire in 2003.

Your son is also a faculty member now at IISc, right?

Yes, I am a mother of two sons. My older son, Tejas, is a faculty member in the Department of Civil Engineering at IISc.

How are you spending your retirement?

Retirement did not mark the end of my professional journey. I committed myself to mastering AutoCAD, and continued to work with an architect for several more years.

Post-retirement, I spent 6-8 months living in the USA with my son. During that time, I discovered a new passion for quilting. I now create commissioned quilts and share my knowledge by teaching quilting. Participating in exhibitions has allowed me to showcase and sell my creations. I also enjoy travelling to nearby places with my friends, taking care of my dogs, and fully enjoying my retired life.

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Abstracts, IISc Photography Club