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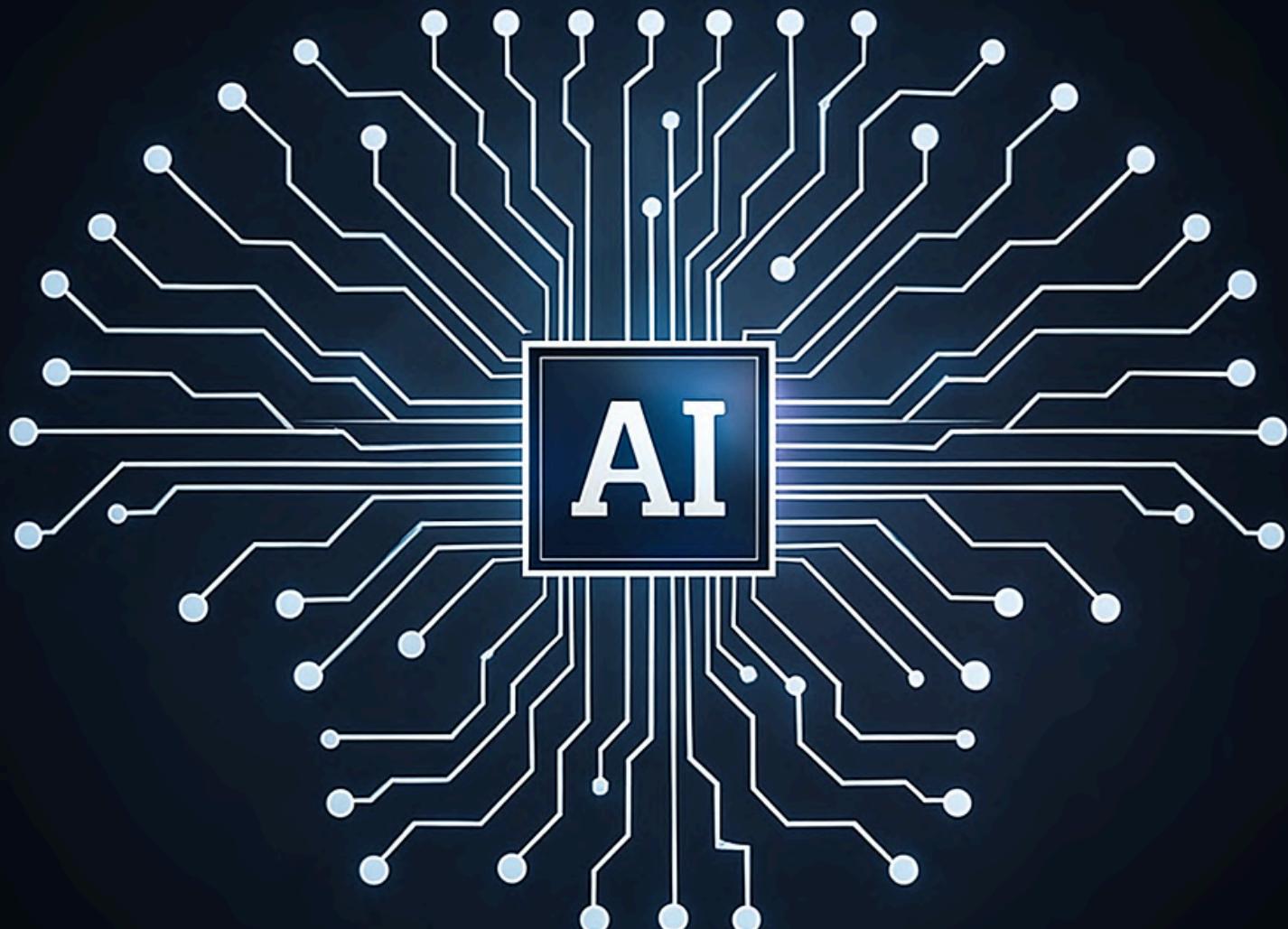
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# SCIENCE FACTORS.

*INSIGHT, DISCOVERY, LEARNING, INNOVATION, AND IMPACT*

By  
Rosalind Franklin  
Council of Scientific Research  
(RFCSR)  
December 15, 2025



AI in Science  
THE NEW ENGINE OF DISCOVERY

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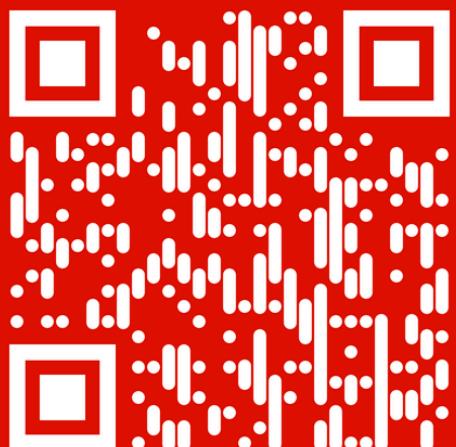
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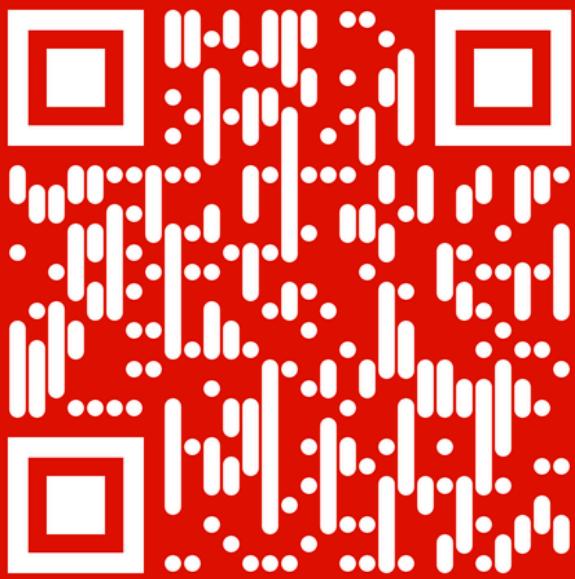
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# LETTER from the EDITOR



Dr. Animesha Rath  
*The Editor-in-Chief*

Dear Readers,

As we close the year with our December issue, Science Factors turns its gaze toward one of the most transformative forces shaping modern research **artificial intelligence in science**. This month's edition, "**AI in Science: The New Engine of Discovery**," explores how human curiosity and machine intelligence are coming together to accelerate discovery across disciplines.

AI is no longer a distant concept confined to computer labs. It now works quietly beside scientists helping decode genomes, design medicines, understand climate systems, model quantum phenomena, and interpret vast datasets that once felt overwhelming. Throughout this issue, you will meet researchers who use AI not as a replacement for scientific thinking, but as a powerful partner that sharpens questions, reveals hidden patterns, and shortens the distance between ideas and insight.

Our featured stories trace AI's impact from the laboratory to the clinic, from wheat fields to hospitals, and from climate models to quantum theory. Alongside these narratives, expert viewpoints reflect on India's growing role at the frontiers of quantum technology and advanced computation fields that will define scientific leadership in the coming decades.

Yet, this issue also reminds us that speed must be balanced with responsibility. As AI reshapes how science is done, transparency, ethics, and human judgment remain essential. Scientific progress is strongest when innovation is guided by care, curiosity, and integrity.

As 2025 draws to a close, we reflect on a year of remarkable scientific momentum and look ahead with optimism. At **Science Factors**, we believe that every algorithm, experiment, and discovery ultimately serves a human purpose: to improve lives, protect our planet, and deepen our understanding of the world.

May this issue inspire you to see science not just as data and technology, but as a shared journey one where human imagination and intelligent tools move forward together.

Happy reading,

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# *The* CONTRIBUTORS

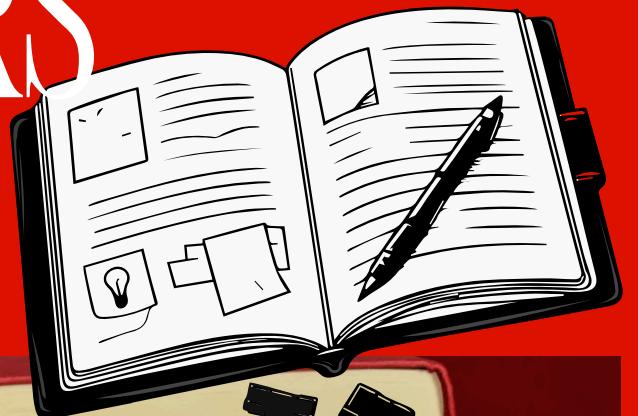
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SCIENTIFIC RESEARCH EMPOWERS SOCIAL PROGRESS !



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**Content Director**

Dr. Avijit Das

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Fuel discovery, inspire the future.

# FEATURED RESEARCH

Behind every discovery lies a story of curiosity, perseverance, and wonder. Science unfolds through relentless research and bold explorations into the unknown. These are the journeys that shape our understanding of the world—and beyond.

By Dr. Sivan Friedman

## AI AT THE SPEED OF DISCOVERY

### FEATURED

Dr. Meera Sen never thought she would feel overwhelmed by science. She had always loved the feeling of discovery, the quiet joy of solving a puzzle after months of experiments. But now, sitting in her small office surrounded by stacks of papers, hard drives full of data, and unanswered emails, she felt stuck. Her lab studied climate-resilient crops, and she had more data than ever before: genomic sequences, satellite maps, soil records, heat-stress trials, and hundreds of time-lapse images. Yet nothing connected. The questions were too big, and the data were too messy. Every day she felt she was walking slower while the problems grew faster.



One afternoon, during a seminar, a visiting scientist introduced a new tool. "Think of AI not as a machine but as an assistant who can scan the entire library of science in minutes," he said. "It won't replace you. It will help your questions move faster." Meera wasn't convinced, but she was curious. Could something really help her see patterns she couldn't even articulate?

A week later, she finally tried it. She fed an early version of her wheat stress-response dataset into an AI platform. The software whirred quietly, processing millions of data points that she would have taken months to examine manually. In less than two minutes, it highlighted three unusual gene clusters that responded to rising temperatures. Meera stared at the screen, stunned. Not because the machine was smarter but because it had shown her a direction she would have never guessed so early. It felt like someone had cleared fog from a mountain path.

Over the next months, her relationship with AI shifted. She learned how to phrase scientific questions more clearly. She learned how to check what the AI suggested and verify whether the patterns actually made biological sense. Slowly, she realized something important: AI wasn't discovering answers on its own. It was amplifying her ability to think.



| By Dr. Sivan Friedman

Meanwhile, in another part of the world, Dr. Paul Richter was studying protein structures involved in a rare disease. His experiments were painfully slow; each protein took weeks to model. When his lab adopted AI-based protein prediction, the pace transformed. What once required a full month now took minutes. Paul still needed to validate everything in the lab, but he could finally test ideas quickly instead of abandoning them for lack of time. His students, who once feared the complexity of structural biology, began running simulations confidently.

Across continents, scientists like Meera and Paul began to notice a quiet revolution. An ecologist could analyze decades of deforestation data in hours. A medical researcher could detect early patterns of tumor evolution. A materials scientist could design and test new alloys virtually before melting a single metal in the lab. Everyone felt a shift not because AI solved everything, but because it changed what was possible.

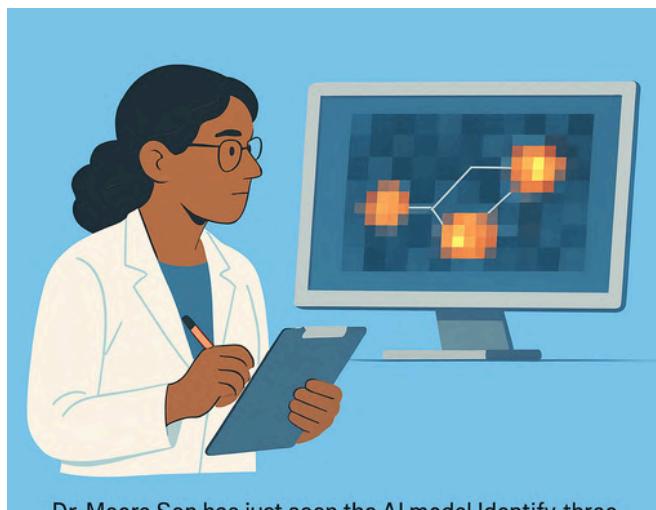
Still, challenges crept in. Data were scattered, stored in different formats, or locked behind old systems. Some researchers didn't trust AI's predictions. Others feared it might mislead if trained poorly. There were debates on ethics, transparency, and access. It became clear that AI needed more than computational power; it needed responsible use, good data, well-trained scientists, and thoughtful oversight.

One evening, Meera stood in her field station, watching her newly tested wheat lines sway in the warm breeze. Her experiments, guided partly by AI insights, had produced plants showing surprising stress tolerance. The results weren't perfect, but they were promising far better than what she had achieved in earlier years.

She finally understood the message of the article she once read: AI doesn't replace scientific intuition. It strengthens it. It pushes boundaries faster. It lets researchers ask bolder questions. It turns months into days and days into minutes. It helps humanity climb mountains that once felt immovable.

As Meera gently touched the wheat spikes, she whispered, "This is not AI's success. It's our success with AI beside us." And in that simple moment, she felt the future of science shift inside her: faster, clearer, more hopeful than ever before.

lay not in providing answers, but in acceleration in giving scientists the time and freedom to think deeper, explore wider, and test ideas once considered unreachable. As dusk settled, she sensed a new rhythm in science, one where human intuition and machine intelligence moved together. AI had not changed the purpose of research, only its pace and reach. The questions remained deeply human, guided by curiosity and judgment, while the possibilities had expanded beyond previous limits. With responsible use and thoughtful oversight, discovery no longer felt distant, but increasingly within reach.



Dr. Meera Sen has just seen the AI model identify three unexpected heat-tolerance gene clusters—far earlier than she would have found manually. The AI provides no explanation, only a pattern.

- A Trust the AI completely and redesign all experiments immediately.
- B Reject the AI output because unexplained predictions aren't scientific.
- C Use AI as a hypothesis generator: verify biologically, cross-check literature, design targeted experiments, and test whether the pattern truly holds.
- D Add more datasets and let AI guide all decisions, reducing the need for experiments.

## REFERENCE:

Gil, D., & Moler, K. A. (2025). Accelerating science with AI. *Science*, 0, eaee0605.

<https://doi.org/10.1126/science.aee0605>

US Department of Energy, Washington, DC, USA,

In that quiet field, Meera realized that the true power of AI

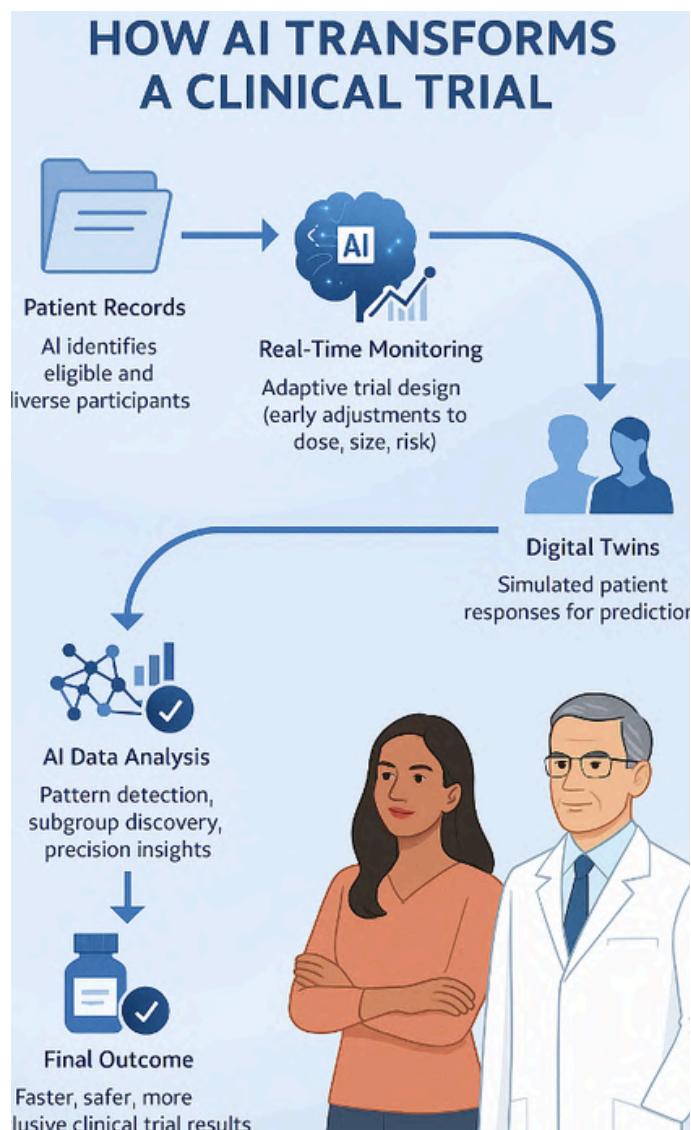
By Dr. Avijit Das

## ASHA AND THE AI TRIAL

### FEATURED

**A**sha was a young clinical researcher working in a busy medical center. Every morning, she walked past long corridors filled with files, reports, and test tubes. She dreamed of helping develop new medicines faster, especially for diseases affecting thousands of people in her country. But she also knew the truth: clinical trials the process of testing if a new treatment works were slow, expensive, and often frustrating.

One afternoon, her supervisor, Dr. Mehra, called her into his office. He looked excited. "Asha," he said, "we're



entering a new era. Artificial intelligence can finally help us fix many problems in clinical trials."

Asha frowned. "AI? For clinical trials? How?"

So Dr. Mehra told her a story not about the medicines themselves, but about the way they are tested.

Traditionally, trials took months or years. Researchers struggled to find the right patients, many trials became too expensive to continue, and some failed simply because not enough people enrolled. Other times, the participants were not representative of real patients too young, too healthy, too similar. As a result, even good drugs took forever to reach hospitals, and many never reached at all.

Dr. Mehra explained that AI could change almost every step of this process.

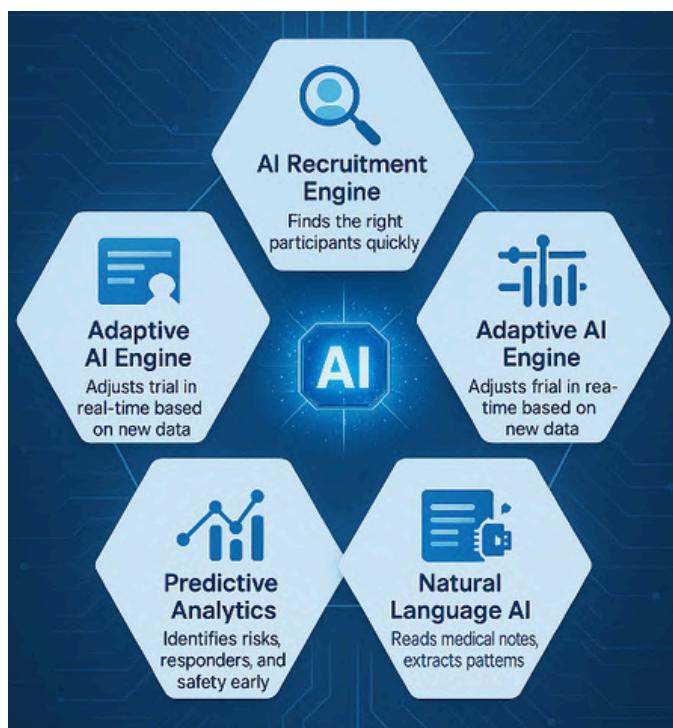
He started with finding the right people for a trial. Normally, researchers had to manually read patient histories, lab results, and medical records. It took ages. But now, AI systems could scan millions of records in seconds and identify who would fit perfectly. Not only that, AI could also suggest making the criteria more inclusive. Instead of choosing only ideal patients, trials could include people of different ages, backgrounds, and health conditions just like real life.

Asha nodded. That made sense.

Next, Dr. Mehra showed her something even more surprising: trials did not have to stay the same from start to finish. With AI, researchers could use adaptive trial designs. Instead of waiting until the end to make changes, AI could analyse early results and recommend adjustments. If a dose was too high or too low, AI would notice. If a treatment seemed promising for a certain group, the trial could shift focus. If the sample size needed to change, AI could suggest it immediately. It was like having a smart assistant watching the trial continuously, helping it run more efficiently and safely.

Asha felt excited but also nervous. "But what about risks?" she asked.

Dr. Mehra smiled. "Good question. That's why we need proper design, regulation, and oversight. AI must help, not replace, human judgement."



He continued with another breakthrough: digital twins—virtual patient models that behave like real people. With AI, researchers could simulate how a drug might act in many types of bodies even before giving it to humans. This could reduce the number of people needed for early-phase trials and prevent dangerous outcomes.

Then came data analysis. Trials produce mountains of information: scans, blood reports, numbers, doctor notes. AI can recognise patterns humans miss, group patients intelligently, and help detect which treatments work best for which individuals. This moves medicine closer to precision health, where treatments match each person's unique biology.

Asha felt amazed. “So AI can speed up trials, improve safety, reduce cost, and include more people?”

“Yes,” Dr. Mehra replied, “but it also means scientists must change how they work.”

He explained that researchers must be transparent about how AI is used: what model, what data, what rules, and how decisions were made. Regulators must update guidelines. Doctors must trust the process. And patients must know AI is used responsibly and ethically.

As she left the office, Asha imagined a new future: medicines reaching hospitals faster, trials becoming more

fair and effective, and research becoming more human-centered even with the help of machines. She realised AI was not replacing scientists; it was giving them superpowers.

That evening, Asha wrote in her notebook:

*“AI will not run clinical trials for us. But it will help us design them smarter, manage them better, and deliver hope sooner.”*

And with that thought, she began planning her first AI-assisted trial—one that might finally bring a much-needed treatment to the world.

A trial team needs to recruit 200 patients in 3 months. Which AI hero helps?

- A Recruitment Engine
- B Digital Twin
- C Document Reader

A dangerous side-effect appears on Day 10. The team must instantly change the trial plan.

- A Adaptive AI
- B Document Reader
- C Recruitment Engine

Before testing on humans, the team wants to run virtual simulations.

- A Recruitment Engine
- B Digital Twin
- C Adaptive AI

## REFERENCE

Badani, A., de Moraes, F.Y., Vollmuth, P. et al. AI and innovation in clinical trials. *npj Digit. Med.* 8, 683 (2025). <https://doi.org/10.1038/s41746-025-02048-5>

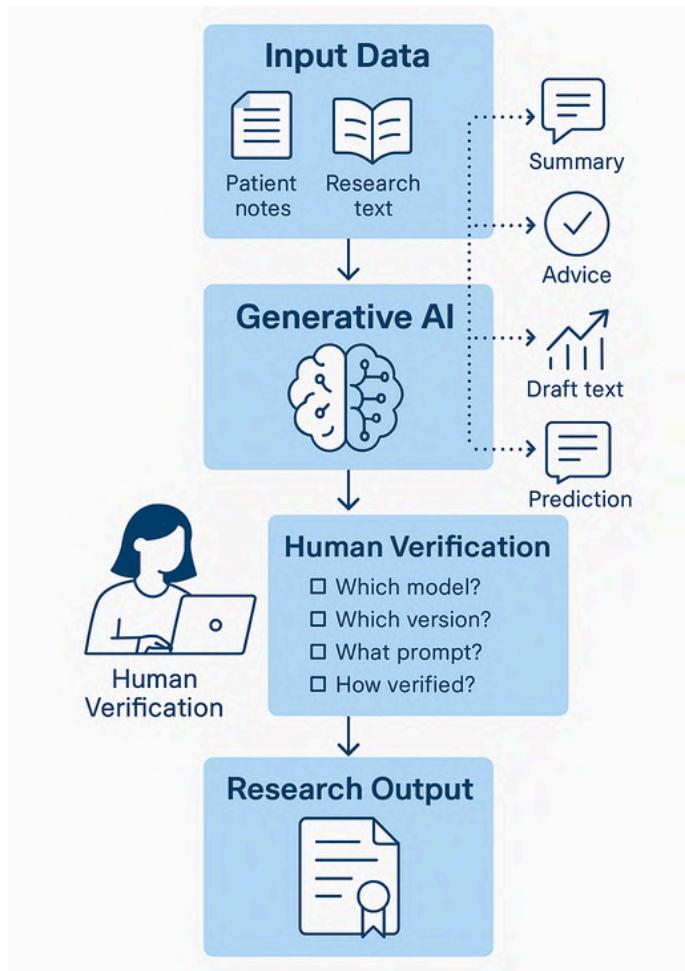
*Department of Neurosurgery, Penn State Health Milton S. Hershey Medical Center, Hershey, PA, USA*

By Dr. Sourav Kumar

# THE RESEARCHER WHO GUIDED AI

## FEATURED

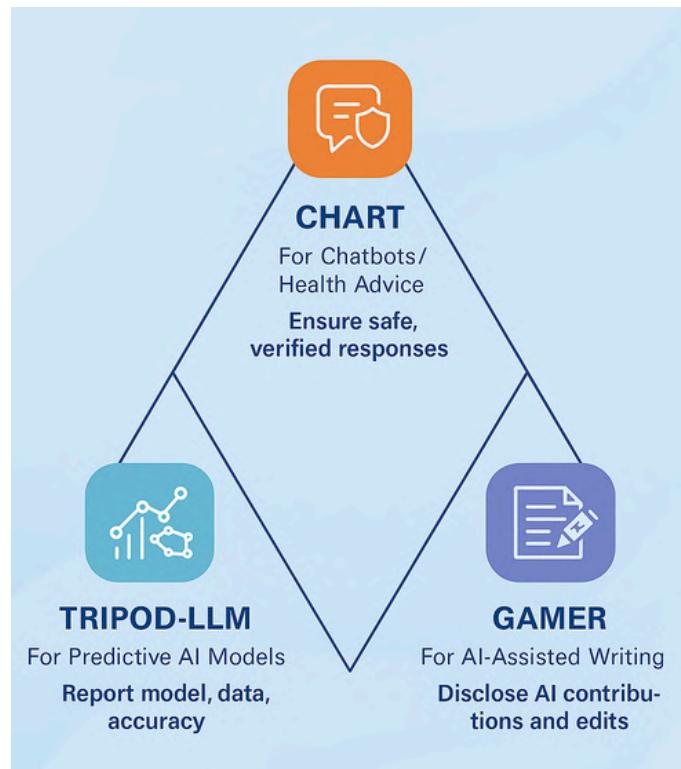
Riya was a young public-health researcher working in a busy hospital. Every day she collected patient notes, long conversations with doctors, survey forms, and health reports. She loved her work but often felt overwhelmed by the amount of information she had to analyse. One afternoon, her professor introduced her to a new tool: a generative AI system that could answer questions, write summaries, organise documents, and even help her write parts of her research report. To Riya it felt like a friendly talking machine that understood everything. She loved how fast it worked. But after a few days she noticed something strange. Sometimes the machine gave perfect answers, but other times it added information that was not true, mixed up facts, or left out something important.



She asked her professor why this happened. He explained that generative AI is powerful but unpredictable, especially in health research where accuracy is critical. That is why researchers must follow clear rules when they use AI and report their findings.

Riya listened as her professor said that in the past, researchers used simple reporting guidelines. These worked when studies involved ordinary statistics or traditional machine-learning models. But generative AI is different because it can create new text, summaries, explanations, and even new mistakes. If a researcher does not explain exactly how the AI was used, it becomes difficult for other scientists to trust the results. Riya realised that AI is like a brilliant but unpredictable student—sometimes answering beautifully, sometimes confidently saying something wrong. So researchers must write down every detail of their process so others can understand and repeat the study.

Her professor said scientists should follow different rulebooks depending on how they use AI. The first is CHART, used when AI works like a chatbot that gives health advice or summarises information for patients or doctors. Using CHART means the researcher explains what questions were asked, how the answers were checked, and whether the advice was safe.



| By Dr. Sourav Kumar

The second is TRIPOD-LLM, for studies where AI predicts something, such as disease risk or clinical outcomes. TRIPOD-LLM asks researchers to explain the model, how it was trained, what data were provided, and how its accuracy was measured. The third is GAMER, used when AI helps write research papers or case reports. GAMER requires authors to explain what the AI wrote and how humans edited and verified the text. As her professor spoke, Riya realised how important it was to choose the right guideline for the right kind of AI use like choosing the correct medical test for a specific problem.

Riya then asked how detailed the reporting must be. Her professor said researchers must be fully transparent. They should mention which AI model they used, which version, the prompt they typed, what parts of the AI's output they kept, what they corrected, how they checked for errors, and what risks or biases they found. Without this information, no one can repeat the study or trust the results. He explained that transparency builds scientific trust, especially in health research where mistakes can cause harm. Riya understood that good reporting is not just a formality; it is a responsibility toward patients, doctors, and society.

As she walked home that evening, Riya thought about everything she had learned. She realised that AI is not magic. It is a powerful tool, but like all powerful tools, it must be used responsibly. If researchers report their AI methods clearly, science becomes more trustworthy and safer. But if they hide details or skip guidelines, their work may mislead others and put people at risk. Riya felt a new sense of purpose. She promised herself that whenever she used AI in her research, she would follow the correct guideline, be honest about the process, double-check the AI's output, and always protect patient safety. With that promise in her heart, she returned to the hospital the next morning ready to work with knowledge and care, beginning a new chapter where she and her "talking machine" would support each other with clarity and respect for good science.

## WHICH GUIDELINE AM I?

Match each scenario to the correct reporting guideline; CHART, TRIPOD-LLM, or GAMER – and give a one-line reason.

1 A chatbot answers pregnancy-related questions for rural women.  
*Which guideline applies?*

2 An LLM reads hospital summaries and predicts patient readmission.  
*Which guideline applies?*

3 A researcher uses AI to write 40% of a manuscript draft.  
*Which guideline applies?*

### REFERENCE

Huo, B., Collins, G.S., Cacciamani, G.E. et al. Reporting guidelines for studies involving generative artificial intelligence applications: what do I use, and when?. *npj Digit. Med.* 8, 646 (2025).

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## INDIA AT THE FRONTIERS OF QUANTUM TECHNOLOGY



**Prof. Apoorva D. Patel**

| Centre for High Energy Physics, Indian Institute of Science (IISc), Bengaluru, India

 | [Scientific Profile](#) |  | [Organization Link](#) |

Areas of Expertise: Non-Perturbative QFT | Lattice Gauge Theory | Renormalisation Group

In 1983, Richard Feynman taught a course at Caltech titled “Potentialities and Limitations of Computing Machines”. It gave an adventurous yet careful introduction to the subject of quantum computation to students such as myself. In the current intense competition for developing quantum technology, with considerable media hype, the notion of what is really practical is being overlooked. It is well-established that the size of quantum advantage is problem-dependent, and it is essential to carefully look at the basic features of quantum theory to figure out where and how it can appear.

Quantum theory originated with the introduction of a new constant of nature, the Planck constant  $\hbar$ . It quantifies the commutator of canonically conjugate pair of coordinates, appears as the minimal area in the structure of the phase space, is the unit of angular momentum and is part of the definition of the energy quantum. The involvement of a nonzero Planck constant is indispensable for quantum effects to appear in an algorithm and lead to quantum advantage. There are many physical phenomena in classical dynamics, where the Planck constant does not appear, and it would be silly to expect quantum advantage in explaining them.

Another fact is that quantum dynamics is highly fragile against external disturbances. The infrastructure needed to shield the quantum signal from environmental noise makes quantum technology expensive. Economics then dictates that quantum technology will be attractive only in cases where the advantage offered by it is sufficiently large to offset its cost. Hence, quantum technology will be practical only as special-purpose devices, as custom subroutines in larger applications. We also need such a hybrid quantum-classical setup to interpret the quantum results, because we live at a classical level.

A quantum state is fully specified by its density matrix  $\rho$ , which generalises the framework of a classical probability distribution. The quintessential quantum features appear in its off-diagonal elements. In the ensem-

ble language, the Boltzmann weight  $e^{-\beta H}$  describes classical probability distributions, while the quantum weights require a more general description such as the Wigner distribution or the Feynman path integral weight  $e^{iS/\hbar}$ . The peculiarities of quantum weights is that they can go outside the real interval  $[0, 1]$ , which is often called the “sign problem”. Weights with a sign problem are mandatory for observing constructive and destructive interference. Furthermore, the expectation value of an observable  $O$  measured for a quantum state is  $\langle O \rangle = \text{Tr}(\rho O)$ . When  $\rho$  and  $O$  commute, their simultaneous diagonalisation reduces  $\langle O \rangle$  to  $\sum_i p_i O_i$ , which can be realised by a classical probability distribution. Quantum features therefore appear only in situations where  $\rho$  and  $O$  do not commute, and the largest quantum effect would appear in a setup where the norm of  $[\rho, O]$  is maximal.

**“Quantum advantage can be obtained only when features of density matrices that are absent in classical probability distributions are exploited”**

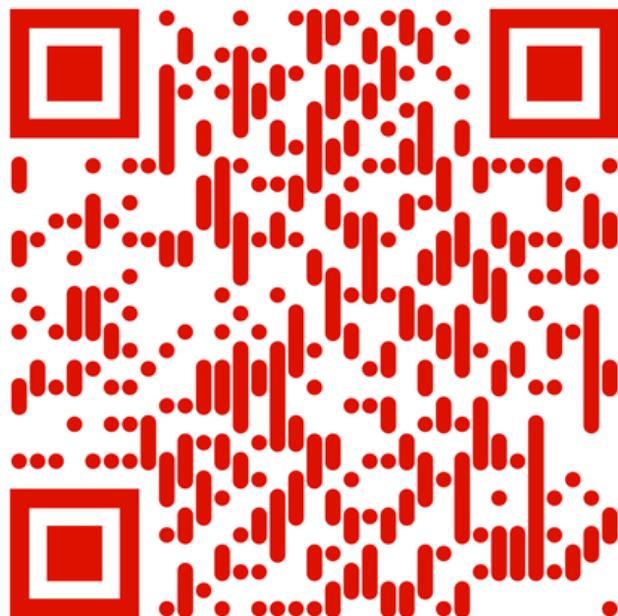
Given all these considerations, the foremost ongoing applications of quantum devices are in the area of high precision sensing and measurements, where small quantum modules are embedded in large classical peripherals. Time, location, movement, rotation, electric field, magnetic field, gravitational field—all physical quantities—can be measured more precisely by quantum devices than by classical ones. That has wide-ranging applications from physics to engineering and medical diagnostics. The next in line are dynamical simulations of physical quantum systems, which can provide information about their quantum correlations and time evolution, and help in the design of new molecules and materials. Going beyond that stage would need technological breakthroughs in controlling fragile quantum signals.

We in India should certainly keep track of worldwide quantum technology developments and learn from them. But given the limitations of available infrastructure and skilled workforce,

we need to judiciously select areas to pursue vigorously. Standout instances based on our capabilities are: (1) Develop quantum design software platforms that can estimate quantum device performance in presence of imperfections. (2) Use these simulators to fabricate elementary quantum components (e.g. various type of qubits, single photon sources and detectors, squeezed states), with high fidelity and good control. (3) Integrate reliable quantum components into quantum devices for high precision sensing, measurement and imaging. (4) Explore quantum-inspired classical algorithms that simultaneously process magnitude and phase information of signals to yield improved performance. (5) Develop quantum-safe classical cryptography, and other strategies to guard against quantum adversaries, along with true random number generators based on quantum phenomena. (6) Use interferometry involving multiple sensors and long time exposures to improve the signal-to-noise ratio in communications. (7) Develop efficient simulation methods for small molecules and their reactions to closely mimic natural processes.

These are all tough challenges, but they can be tackled with  $O(10)$  qubit systems. They require collaborative sustained and focused effort, while providing full freedom of exploration to scientists. They are also within our reach, as we have demonstrated while indigenously developing nuclear technology and space technology.

**“**Quantum advantage can be obtained only when features of density matrices that are absent in classical probability distributions are exploited.”



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## REFLECTIONS ON MY RESEARCH IN QUANTUM COMPUTING AND INFORMATION IN INDIA



GLOBAL TOP 2% SCIENTIST

### Prof. Arun Kumar Pati

| Centre for Quantum Technology, KIIT University, Bhubaneswar, India

 | [Scientific Profile](#) |  | [Organization Link](#) |

Areas of Expertise: Quantum Computing | Quantum Information | Quantum Communication | Quantum Technology

World Leader in Quantum Information Science | Pioneer of Indian Quantum Computing

Quantum computing and quantum information science represent one of the most profound revolutions in our understanding of nature. Over the past three decades, my work from the **no-deleting theorem**, **no-hiding theorem**, **no-masking theorem**, **remote state preparation**, **the quantum speed limits**, and **quantum acceleration limit** has consistently revealed one central truth: information is a physical entity, and quantum information is richer than anything classical physics can offer.

The no-deleting, no-hiding, and no-masking theorems form the foundational pillars of quantum information theory by revealing how quantum information behaves in ways fundamentally different from classical data. The no-deleting theorem shows that quantum information, once created, cannot be perfectly erased; the no-hiding theorem proves that when information appears to “vanish,” it must move to another physical system; and the no-masking theorem establishes that quantum information cannot be concealed solely within correlations. Together, these results highlight the intrinsic indestructibility and delocalized nature of quantum information properties essential for secure quantum communication and robust quantum memory. Concepts like remote state preparation further demonstrate how quantum entanglement allows a quantum state to be prepared at a distant location using only classical communication and shared entanglement, an operational tool for distributed quantum networks. Meanwhile, quantum speed limits (QSL) and the recently

discovered quantum acceleration limit (QAL) quantify how fast and how sharply quantum states can evolve, placing ultimate physical bounds on computation, control, and information processing. In quantum computing, these principles guide the design of high-speed logic gates, fault-tolerant architectures, secure communication protocols, and optimal algorithms by clarifying what is fundamentally possible and impossible in the quantum world.

“Information is a physical entity, and quantum information is richer than anything classical physics can offer.”

India stands at the threshold of becoming a global leader in quantum technologies. Our biggest opportunity lies in harnessing our strengths strong theoretical foundations, a vast scientific talent pool, and a rapidly growing technological ecosystem to develop indigenous quantum computers, quantum communication networks, and high-precision quantum sensors. India can leapfrog traditional technological pathways by building on deep quantum principles such as entanglement, coherence, and quantum resource theories. If we act strategically, India can become not just a user of quantum technologies, but a creator of fundamental discoveries, shaping global scientific directions.

Over the next ten years, India must invest in three pillars: (1) Quantum infrastructure: Build national quantum labs with superconducting, photonic, trapped-ion, and spin-based platforms. A Quantum Technology

Institute with international standards would accelerate innovation. (2) Human capital: Establish dedicated quantum research institutes, doctoral programs, fellowships that attract and retain world-class talent. (3) Translation and industry: Create strong academia industry partnerships for quantum computing hardware, quantum-safe communication, satellite quantum links, quantum-enhanced healthcare diagnostics, and defence applications.

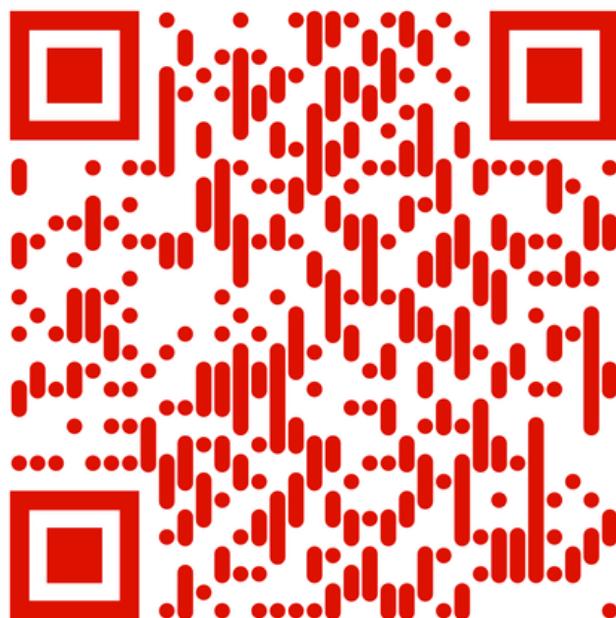
To young researchers, I offer this advice: cultivate depth of thought, not just technical skill. The greatest breakthroughs in quantum information from no-cloning to quantum teleportation came from questioning fundamental assumptions. Develop strong foundations in mathematics, physics, and computer science. Choose problems that challenge your intuition. Be patient, persistent, and intellectually fearless. Above all, remember that quantum mechanics still holds mysteries; many of my own works, including no-go theorems, quantum information protocols, uncertainty tradeoffs, and quantum correlations, emerged from exploring these subtle gaps. At the same time, the younger generation should also be motivated to pursue the experimental side of quantum technology. That is where you will see new ideas get translated to real world applications.

India's quantum future will be shaped by the curiosity and creativity of the next generation. The field is vast, beautiful, and filled with possibilities and now is the best time to contribute.

“

*Information is a physical entity, and quantum information is richer than anything classical physics can offer,*

”



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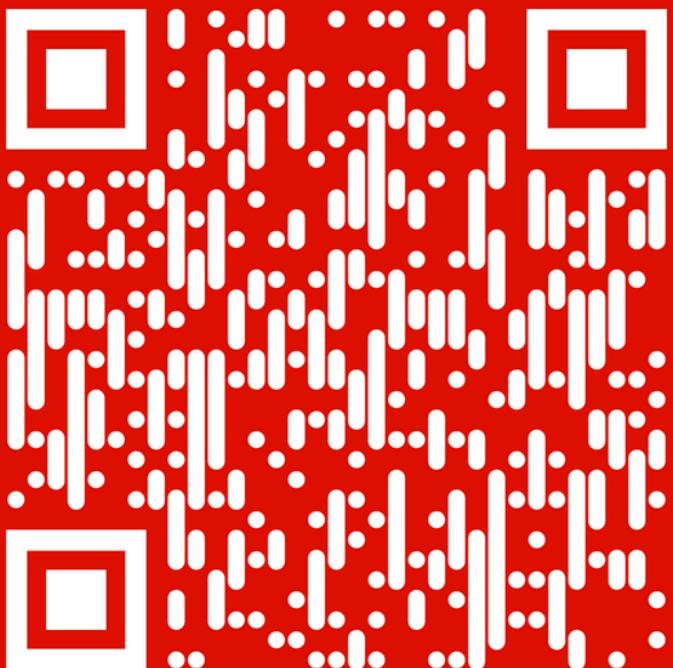


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- Work more efficiently
- Make smarter career or subject choices
- Feel confident in your abilities
- Enjoy what you do, every day

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## PROBING LIFE IN MOTION: ADVANCED EPR SPECTROSCOPY AT THE INTERFACE OF BIOLOGY, CHEMISTRY, AND COMPUTATION

*Your research spans advanced EPR spectroscopic techniques (CW EPR, DEER, ENDOR, EDNMR) to investigate disordered proteins and metalloproteins. What inspired you to focus on this interdisciplinary area, and how has your vision for biomolecular EPR evolved since you started your lab?*

My research is driven by the unique versatility of advanced Electron Paramagnetic Resonance (EPR) spectroscopy, which naturally bridges chemistry, physics, and biology. Despite major advances in AI-based structure prediction tools such as AlphaFold, understanding the structure and dynamics of disordered proteins remains highly challenging, and EPR is uniquely suited to probe such systems. Metalloproteins, which often contain EPR-active paramagnetic centers, play central roles in catalysis and electron transfer, making the characterization of their electronic structures in resting states and reactive intermediates essential. Over time, my vision has expanded beyond purified systems toward more complex biological environments, including native and *in vivo* contexts. Advances in EPR methodology and instrumentation have also broadened its applicability to other frontiers such as materials chemistry and nanobiotechnology.

*Disordered proteins and reactive metalloprotein intermediates pose major challenges in molecular biophysics. What is the most critical unanswered question in this space today, and how is your group addressing it?*

For disordered proteins, a central unanswered question is how transient local interactions and conformational dynamics translate into long-range functional regulation within the crowded cellular environment. In metalloproteins, the challenge lies in trapping and accurately characterizing highly diverse reactive intermediates, whose electronic structures are sensitive to subtle changes in coordination environments. My group addresses these challenges using advanced EPR methodologies integrated with computational tools and complementary spectroscopic techniques such as NMR, FRET, and rapid freeze-quench methods to capture functionally relevant intermediates.

*How do you see the future of biomolecular spectroscopy evolving, and which emerging technologies excite you most?*

Biomolecular spectroscopy is evolving toward hybrid,

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Areas of Expertise:  
Biophysics | EPR Spectroscopy |  
Bioinorganic Chemistry



integrative approaches that combine EPR with Cryo-EM, NMR, mass spectrometry, and AI-driven modeling. Long-range distance constraints from EPR/DEER (1.5–10 nm), particularly for flexible disordered regions, will be critical for validating structural reconstructions from Cryo-EM. New experimental protocols are also expected to bridge the gap between solution-based and *in-cell* spectroscopy. I am particularly excited to integrate Cryo-EM and AI-based computational modeling with EPR to study structure and function in their full biological context.

*Which interdisciplinary collaborations could significantly expand the impact of your research?*

Major breakthroughs often emerge from interdisciplinary research. Collaborations with computational scientists specializing in AI, machine learning, and molecular dynamics can enable accurate prediction of functional conformational ensembles. Partnerships with materials scientists and nanotechnologists can further extend our work toward designing robust, enzyme-mimicking catalysts with industrial relevance.

*What guidance would you offer to young scientists entering this field?*

Addressing such complex problems requires a strong interdisciplinary foundation that integrates spectroscopy, biochemistry, and computational tools. EPR should not be treated as an endpoint, but interpreted alongside complementary spectroscopic methods, Cryo-EM, and computational analysis to achieve a comprehensive molecular understanding. For young scientists entering this field, I encourage a problem-driven approach focused on real-world challenges, including uncovering molecular mechanisms of disease and designing efficient catalysts to address environmental problems.

## MOLECULAR SWITCHES AT THE FRONTLINE: G-PROTEIN SIGNALING AND PLANT DEFENSE AGAINST PATHOGENS

*What motivates your research on G-protein-mediated defense, and what curiosity do you seek in students joining your lab?*

During my undergraduate and master's studies, I became deeply interested in G-protein-coupled signaling, as these molecular switches relay extracellular signals into precise cellular responses. While these pathways are well characterized in animals, their roles in plants remain less understood, particularly in defense. This knowledge gap motivated my Ph.D. research on G-protein signaling in plant defense. In my lab, I seek students who are curious about how G-protein-mediated pathways translate external cues into coordinated defense and developmental responses in plants.

*How do you study fungal penetration mechanisms, and how do you encourage students to think creatively about plant protection?*

To study the fungal penetration mechanism, we used various localization and omics-based techniques. We used fungal mutants tagged with GFP or RFP fluorescence proteins to infect plant samples and trace the disease progression in the plants. We also used transcriptomics to check the dynamics of RNA expression involved during pathogen infection. I encourage students to think creatively by suggesting them to integrate molecular biology with bioinformatics, ecology, or systems biology to solve the global food security.

*How can your discoveries on cutinases and plant surface defenses shape future crop resistance, and how do you train students to connect mechanisms to field relevance?*

Cutinase are enzymes that are the first effectors being released from the fungal pathogens to penetrate the plant surface. By uncovering how cutinases interact with surface defense mechanisms, we can better understand the early stages of pathogen invasion. Likewise, a stronger plant surface having higher cuticle components may resist the pathogen entry. I encourage students to think beyond the lab bench linking biochemical findings to physiological outcomes and agricultural applications.

*What excites you about the industrial potential of microbial enzymes and metabolites, and how do you nurture entrepreneurial and translational thinking in your group?*

Microbial enzymes have huge industrial potential and the exciting thing about them is that they are versatile, meaning they can digest their substrate from a wide range

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Areas of Expertise: Plant–Pathogen Interactions | Molecular Mechanisms of Disease Resistance | G-Protein Signaling in Plants



of plant species. Microbial enzymes can convert agricultural waste into useful products and have tremendous commercial potential to produce biofuel, fatty acids and biocontrol agents. In my group, we are working on how we can isolate and modify enzymes by genetic engineering and I encourage students to apply knowledge to create their own startups to become entrepreneurs.

*What cutting-edge tools will power your lab's next phase, and how do you support students in mastering advanced techniques with confidence and integrity?*

In the next phase of my lab, I aim to use cutting-edge tools such as targeted gene editing using CRISPR/Cas-based genome editing, high-resolution imaging and advanced omics approaches (transcriptomics, proteomics, and metabolomics) to solve the unanswered questions. To help students to become experts in these advanced techniques I mentor them to learn these techniques and ask why and when to use it.

*How do you envision the future of plant disease resistance research, and what role do young scientists play in shaping it?*

The future of plant disease resistance research lies in integrating molecular insights with systems-level understanding and real-world applications. Advances in genomics, genome editing, and multi-omics approaches will enable us to uncover complex defense networks rather than single resistance factors. Young scientists play a crucial role in this transition by bringing interdisciplinary thinking, technological fluency, and fresh perspectives. I encourage them to ask fundamental questions, embrace emerging tools responsibly, and connect basic research with agricultural challenges, ensuring that discoveries translate into durable, sustainable solutions for global food security.

## FERMENTED FOODS AND GASTROINTESTINAL HEALTH

Food fermentation has its roots back to ancient generations and is nothing but a means to preserve the food when there are no refrigerators available. Fermented foods are prepared using microbial conversion of major and minor food components, which commonly include dairy based products like curd, south Indian staples such as **idli** and **dosa**, fermented soy products from northeast India like **kinema** and **hawaijar**, sweet desserts like **srikhand** and drinks like kombucha and many others. These foods are claimed to have manifold health benefits; however, the claims lack scientific evidence and must be subjected to experimental validation.

In line of this, our group is investigating the effects of fermented food consumption on gastrointestinal (GI) health among traditional fermented food consuming ethnic population of Sikkim, India where fermented foods are an integral part of daily diets, through inspecting and understanding the alteration/modulation in the oral and gut microbiome. Microbiome is a community of characteristic microorganisms colonizing a particular habitat. Oral and gut microbiome, which respectively refers to collection of microorganisms in the oral cavity and GI tract, is reported to be involved in key physiological functions such as digestion and immune functions. The microorganisms produce enzymes which digest food and return important metabolites to human health. The oral and gut microbiome are regulated mostly by diet. For example, healthy eating keeps the microbiome happy and sound. However, any perturbations in microbiota composition can lead to onset of diseases.

In a broadest sense, the impacts of the study may shed insights about the quality and safety of the fermented foods consumed in the region linking to digestive health. The findings may further encourage similar studies across other regions/states of India as well as other parts of the globe where fermented foods and beverages are fundamental part of cultures and traditions. Furthermore, effects of specific fermented foods on the oral and gut microbiome are going to have welcoming opportunities towards development of precision functional foods for healthy life.

But challenges still persist. As these studies are exploratory in nature, it becomes somewhat difficult to collect accurate information on key factors influencing the

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Areas of Expertise: Fermented Foods & Gastrointestinal Health | Diet–Microbiome Interactions | Oral and Gut Microbiome Analysis



microbiome, for example, if a subject/patient is really consuming alcohol or a regular smoker or not as alcohol consumption and smoking are both known to influence the microbiome composition. Secondly, what if the information/data we are getting is a cumulative effect of too many factors rather than a single factor which we are studying. Lastly, it is increasingly cumbersome to define control or healthy population as there are so many criteria that need to be considered to declare someone healthy.

For the young minds who are working or interested in working on human microbiomes, I would suggest working in a more planned way keeping in view of the reported challenges. As more and more studies on human microbiomes will grow, scientists and medical practitioners get to know more about the microbiome and their activities with respect to host and environmental factors, it will be likely to apply more rigorous standards. After all, our main aim is to offer better guidance to the general public to take best care of their own microbiomes.

Looking ahead, integrating longitudinal study designs, standardized dietary assessments, and advanced multi-omics analyses will be essential to strengthen causal interpretations. Collaboration between microbiologists, nutritionists, clinicians, and data scientists will further improve study robustness. Such integrative approaches will not only refine our understanding of diet–microbiome interactions but also support evidence-based dietary recommendations, culturally informed nutrition policies, and the development of safe, region-specific functional foods tailored to diverse populations.

# SCIENCE STORIES RESEARCH & EXPLORATIONS

Behind every discovery lies a story of curiosity, perseverance, and wonder. Science unfolds through relentless research and bold explorations into the unknown. These are the journeys that shape our understanding of the world—and beyond.

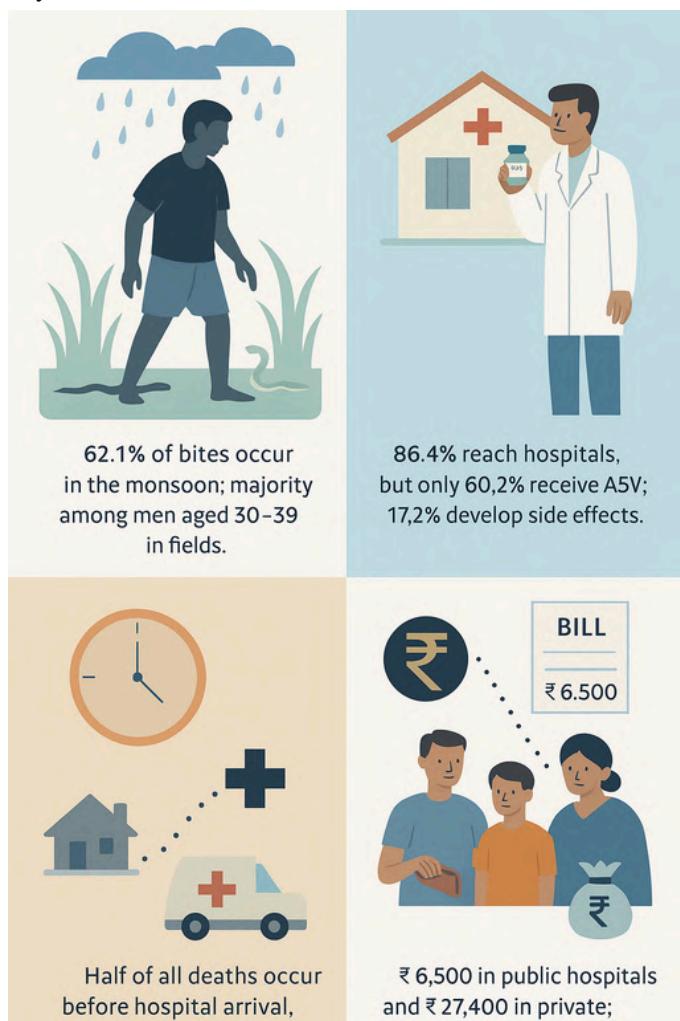
I By Dr. Jnana Ranjan Prusty

## THE DAY THEY DECIDED TO COUNT EVERY BITE

**O**n a warm afternoon at the edge of the monsoon season, a farmer named Raghav was clearing weeds along his rice field when he felt a sudden sting on his ankle. At first, he thought it was a thorn. But when he looked down, he saw the patterned scales of a snake disappearing into the grass. His heart sank. He knew this happened often in his village sometimes to workers in the fields, sometimes to children walking home from school. But Raghav also knew that no one really kept track of how many people were bitten, how many reached a hospital, or what happened to them afterward. Most families talked quietly about snakebites, but the true scale of the problem remained hidden.



This was exactly the reason a team of researchers arrived months earlier in Raghav's district. His home was one of 25 districts across 11 states, together representing nearly 60 million people, chosen for one of India's largest community-level surveys on snakebite envenoming. Instead of relying only on hospital records which miss many cases the team visited households directly. Over one year, they collected detailed information on every bite they could find. By the end, they had documented 7,094 snakebite cases, creating the clearest picture so far of a health problem that affects rural India more than almost anywhere else in the world.



As the data came together, clear patterns emerged. The survey found that 64.1% of victims were men, most between 30 and 39 years old the age group most involved in farming and outdoor labour. Raghav's own case fit these numbers. The researchers noted that human–snake contact rises sharply when fields are active, grass is tall, and workers spend long hours with their feet in the soil.

| By Dr. Jnana Ranjan Prusty

Season also mattered. The monsoon months alone accounted for 62.1% of all bites, as snakes are displaced by flooding, visibility reduces, and farm work intensifies. For many villagers, these seasonal patterns were known through experience; now, they were backed by large-scale data.

The survey also captured clinical details. Many bites came from non-venomous snakes, but the most serious cases involved India's "big four" venomous species. Encouragingly, 86.4% of victims managed to reach a hospital, showing improved awareness and access to medical care. But treatment varied widely. Only 60.2% received anti-snake venom (ASV), the recommended treatment for venomous bites. Among those who received ASV, 17.2% experienced side effects, ranging from mild allergic reactions to more serious complications. Some survivors continued to report health problems long after the bite including wound issues and, occasionally, nerve-related symptoms reminding researchers that snakebite does not end when the venom is neutralized.

The study also highlighted gaps in emergency response. The mortality rate was 0.33 deaths per 100,000 population, but nearly half of all deaths occurred outside hospitals, before victims could reach medical care. Many villages lacked fast transport, lived far from facilities stockpiled with ASV, or depended on traditional remedies that delayed treatment. These delays often turned a treatable bite into a fatal one.

The economic findings revealed another layer of impact. Treatment in public hospitals cost families a median of ₹6,500, while private care averaged ₹27,400 a huge burden for rural households. The survey showed that nearly 50% of victims were from below-poverty-line families. A single bite could erase savings, push families into debt, or force them to sell livestock or land. In Raghav's case, the cost of treatment was almost equal to the earnings of one full month of hard labour.

When the survey results were shared in Raghav's village, the community finally saw their experiences reflected in numbers from across the country. What once felt like isolated incidents now formed part of a national pattern shaped by season, occupation, access to care, and economic vulnerability.

The researchers concluded that snakebite is not just a biological event; it is a health, social, and economic challenge that requires better ASV distribution, faster transport systems, improved rural healthcare, and financial protection for low-income families. For villages like Raghav's, the year of counting brought something important: clarity, and with it, the chance for better preparedness and better outcomes in the future.



If you were the first responder in his village, what would be the first scientific decision you should take and why?

- A Tie a tourniquet tight above the bite
- B Wash the wound vigorously with mud-free water
- C Ask Raghav to walk home slowly
- D Immobilize him and call for transport to the nearest clinic

#### REFERENCE

Menon, J.C., Bharti, O.K., M S, A. et al. (2025). Cross-sectional survey of the incidence, mortality and socioeconomic burden of snakebite envenoming in India. *Nature Communications*, 16, 9871. <https://doi.org/10.1038/s41467-025-64849-2>

*Department of Adult Cardiology, Amrita Institute of Medical Sciences, Amrita Vishwa Vidyapeetham, Kochi, Kerala, India*

By Dr. Ipsita Mohanty

## THE REAL-WORLD IMPACT OF ROTAVAC IN INDIA'S CHILDREN

Every morning, Dr. Anaya walked through the children's ward of a busy hospital in Chennai. For years, she had seen the same heartbreaking pattern: babies and toddlers lying weak on their beds, dehydrated, vomiting, and crying from stomach pain. Almost all of them suffered from severe diarrhea caused by rotavirus, a virus that spread very easily among young children. Many families traveled long distances to reach the hospital, hoping their children would survive. Some did not make it in time.

Before 2016, rotavirus was one of the biggest causes of severe gastroenteritis in India. It filled hospital beds every monsoon season and often pushed poor families into financial stress. Even if the disease rarely caused death

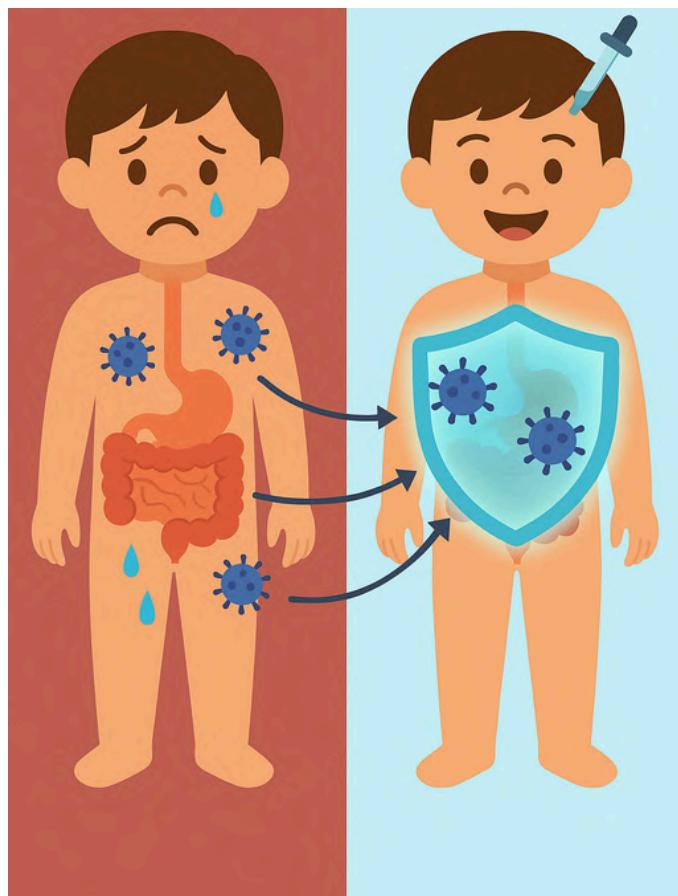


inside big hospitals, it caused enormous suffering. Dr. Anaya often wished for a solution that could prevent children from getting so sick in the first place.

Then came Rotavac, a rotavirus vaccine developed in India. It was added to the national immunization program so that every child could receive it for free. Many doctors were hopeful, but they also wondered: Would the vaccine really work in everyday, real-world Indian conditions? India had different climates, hygiene levels, and virus strains compared to clinical trial settings.

To answer this, a large group of researchers launched a multi-hospital study. They collected data from children under five who were hospitalized for acute gastroenteritis. They tested stool samples to check whether rotavirus was responsible for each child's illness. Then they compared the number of rotavirus-positive cases before and after the national rollout of Rotavac.

As the months passed, the researchers began noticing something remarkable. Fewer children were coming in with rotavirus infections. The drop was not small—hospital



By Dr. Ipsita Mohanty

records across several states showed that rotavirus-positive hospitalizations had fallen significantly after the vaccine was introduced. This meant the vaccine was working exactly as hoped in the real world, outside the controlled environment of clinical trials.

Dr. Anaya felt the change too. The gastroenteritis ward, once crowded and noisy, began to feel calmer. She noticed more empty beds, fewer emergency admissions, and parents who looked less frightened. Mothers would still come in with sick children, but many cases were mild and not caused by rotavirus anymore. She felt relief—not just as a doctor, but as a mother herself.

The study went even deeper. Researchers looked at different rotavirus genotypes, because the virus has many strains. They wanted to know if the vaccine worked against all of them or only a few. The results showed that Rotavac offered strong protection across several major circulating genotypes in India. This was important because virus strains often change over time.

They also examined different ages. The vaccine seemed to give the strongest protection in the youngest children, who are also the most vulnerable. This meant the vaccine was succeeding where it mattered most.

Of course, not everything was perfect. Because the study was observational, it could not control every factor. Hygiene improvements, seasonal changes, or hospital admission rules might also affect the number of cases. But even after considering these issues, the evidence was clear: Rotavac was making a real, measurable difference in children's lives.

With these findings, India became an important example for other low- and middle-income countries. If such a vaccine could work across India's vast, diverse population, it could work elsewhere too. Public-health experts from other nations began watching India closely, considering whether to adopt similar vaccination programs.

One evening, Dr. Anaya stepped into the ward and saw a small boy playing with a toy car beside his mother. He had diarrhea, but the tests showed it wasn't rotavirus. His condition was mild, and he would go home soon. His mother smiled and said, "Doctor, he got all his vaccines."

Dr. Anaya smiled back. In that moment, she understood what the research numbers truly meant: fewer sick

children, fewer terrified parents, fewer sleepless nights in crowded hospital wards. The vaccine was not just statistics it was hope, health, and a quiet revolution saving thousands of young lives across India.



**Which data would give them the MOST reliable answer?**

- A The number of children who visited parks last year
- B The number of hospitalized children who test positive for rotavirus before vs. after vaccine introduction
- C The price of antibiotics in the last 5 years
- D The number of new pediatric doctors hired

#### REFERENCE

Rotavirus vaccine reduces gastroenteritis hospitalizations in Indian children. *Nat Med* 31, 3622–3623 (2025).

<https://doi.org/10.1038/s41591-025-04034-6>

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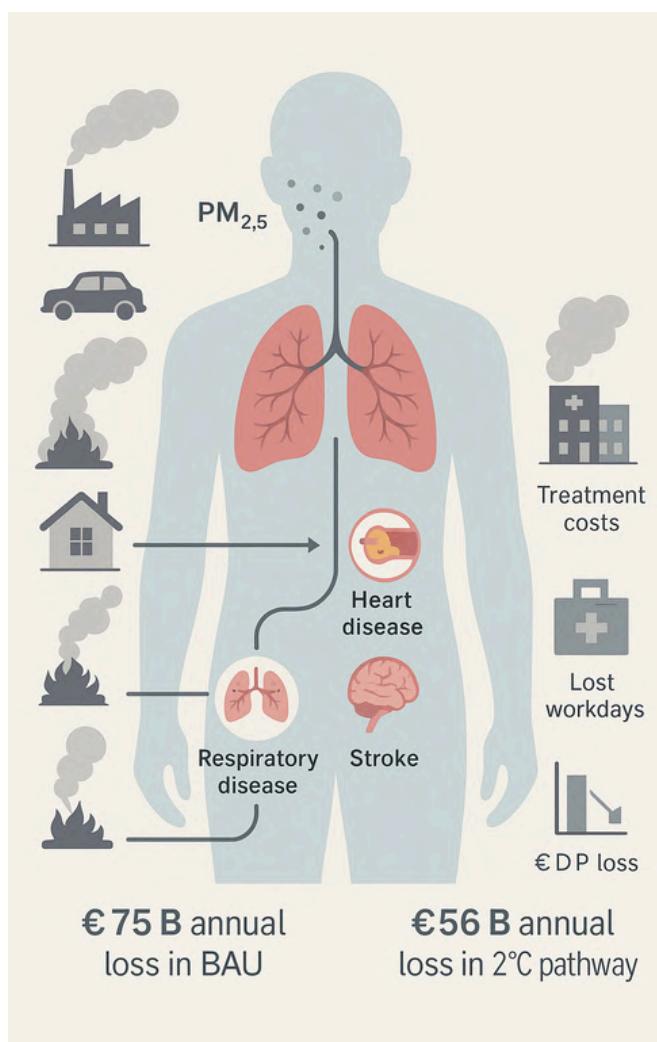
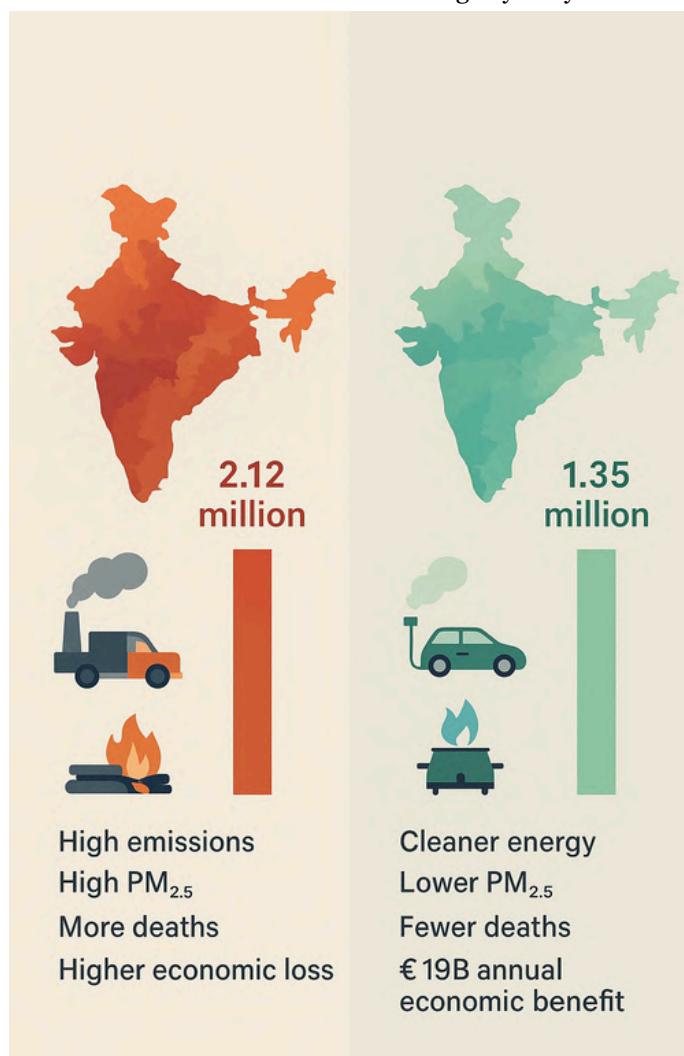


By Dr. Preeti Sharma

## THE STORY OF INDIA'S FUTURE AIR

Rohan was a schoolteacher in a small town near Lucknow. Every day he cycled to school through a thick fog that clung to the morning air. But everyone in the town knew this fog was not mist – it was pollution from burning crop stubble, exhaust from trucks, smoke from cooking fires, and fumes from small factories. Rohan had grown used to the sharp sting in his throat, but his father's cough had grown worse with each passing year. Many elders in the village struggled to breathe, especially in winter. Rohan often wondered what the air would be like when his students grew up and had children of their own.

Far away, in a research centre in Delhi, a team of scientists was thinking about the same question. They wanted to understand how India's air would change by the year 2050.



They were not only interested in the environment they wanted to know what polluted air would do to people's health, how many lives it would affect, and how much it would cost the country. To answer this, they imagined two different futures for India.

The first was called the "Business-As-Usual future." In this future, India continued on its current path with no major new pollution controls or climate actions. Factories kept using old technology, waste continued to be burnt in many places, and households continued relying on polluting fuels in several regions. When the scientists ran their model of this future, the picture was frightening. The amount of tiny toxic particles in the air, called PM<sub>2.5</sub>, stayed extremely high. In many regions, the air pollution was just as bad as today, or even worse. Their calculations showed that by 2050, more than two million Indians every year would die early because of polluted air.

| By Dr. Preeti Sharma

The second future was very different. It was called the “2-Degree Future,” because it followed the actions needed globally to keep warming below 2 °C. In this future, India took bold steps: cleaner fuels, stricter vehicle standards, better waste management, cleaner factories, fewer smoky fires, and strong climate policies. When the scientists ran this model, the map of India began to change. The red and dark zones of pollution slowly turned lighter. In cities and villages, the amount of PM2.5 fell sharply. In this future, nearly eight lakh deaths every year would be prevented simply because the air became cleaner.

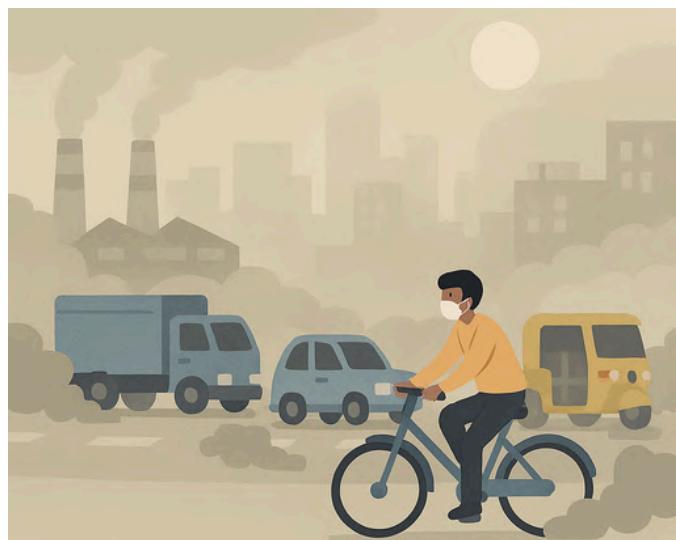
Rohan imagined his students living in this second future. He pictured little Kavya, who often struggled with asthma, walking to school without coughing. He imagined his father breathing peacefully at night, without the long coughing spells that kept the household awake. The more he thought about it, the more real the hope felt.

But the scientists were not done yet. They wanted to understand another important question: What did these futures mean for India’s economy? After all, unhealthy air costs money: people miss work, families spend on medicines, and the country loses productivity. When they added up all these economic losses, the results were striking. If India stayed on the Business-As-Usual path, the country would lose about €75 billion every year by 2050 because of sickness and early death. But if India chose the cleaner 2-Degree Future, the losses dropped to €56 billion. That meant India could save nearly €19 billion every year simply by cleaning its air.

The benefits were even more powerful in poorer states, where household smoke and waste burning are common. For these regions, cleaner air meant healthier families, fewer hospital visits, and stronger local economies.

One day, Rohan told his students about the two futures. “Imagine India standing before two roads,” he said. “One road leads to darker skies and more sickness. The other road leads to clean air, healthy families, and a stronger nation. The future depends on which road we choose.”

As the students looked up at the dusty sky above them, they imagined a brighter version of India, one where clean air was not a dream but a reality created through courage, science, and wise decisions.



**India can save nearly €19 billion every year and prevent eight lakh deaths by choosing the cleaner 2-Degree Future.**

If the benefits are so large, what is the biggest challenge India might face in actually achieving this cleaner future?

- A) People do not know what PM 2.5 is
- B) Cleaner technologies and policies require upfront investment and strong coordination
- C) Pollution disappears automatically after 2050
- D) Schools will stop teaching about air quality

#### REFERENCE

Sarkar, D., Imam, F., Kumar, A. et al. (2025). Air pollution health and economic co-benefits of keeping warming below 2°C in India. *npj Clean Air*, 1, 30. <https://doi.org/10.1038/s44407-025-00031-8>

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I By Dr. Dhanashree Mundhe

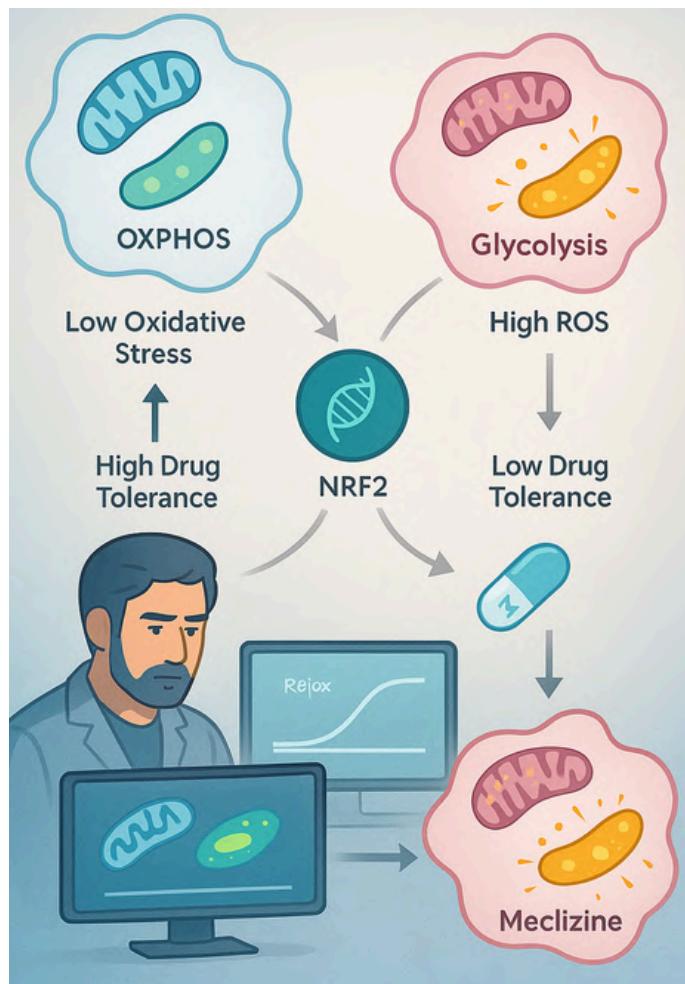
## THE HIDDEN KEY TO BEATING TB

Dr. Ishaan Mehta had always believed that tuberculosis was a clever disease, but one late evening in the lab, he realized it was far more cunning than anyone had imagined. Despite strong antibiotics, some *Mycobacterium tuberculosis* (Mtb) bacteria simply refused to die. They were not genetically resistant; they were drug-tolerant, hiding deep inside immune cells and waiting for their chance to return. This hidden survival strategy was the reason TB treatment took six long months and why relapses were so common. It frustrated doctors, confused researchers, and left Ishaan wondering whether the secret to defeating TB lay somewhere entirely unexpected: not in the bacteria, but in the host itself. The idea felt bold, even strange, yet something told him it was worth exploring.

Ishaan's team wanted to know: What exactly protects these bacteria inside the body? To find out, they infected macrophages, immune cells that swallow bacteria with



Mtb. They used a glowing biosensor called Mrx1-roGFP2, which acted like a thermometer for oxidative stress. Under the microscope, the bacteria lit up in different shades depending on whether they were experiencing oxidative pressure or a calm, "reductive" internal environment.



After weeks of imaging, a pattern appeared that Ishaan couldn't ignore. Some macrophages made Mtb glow brightly, showing high oxidative stress. Others kept the bacteria dim, signaling low stress. And something striking became clear: the bacteria experiencing low stress were the ones surviving antibiotic treatment. It was as if the macrophage was unintentionally protecting them, creating tiny safe houses inside the immune system itself.

This led to a radical question: Could the metabolism of the host cell not the bacteria determine whether Mtb becomes drug-tolerant?

To test this, Ishaan's team compared two metabolic states of macrophages. Some cells ran on oxidative phosphorylation (OXPHOS), a high-energy process that

| By Dr. Dhanashree Mundhe

uses oxygen to create ATP. Others relied heavily on glycolysis, a faster, sugar-based energy pathway commonly activated when immune cells fight infections. The results were dramatic. Macrophages using mostly OXPHOS created a relaxed environment for Mtb. In these cells, the bacteria stayed in a reductive redox state, experienced little oxidative stress, and became highly tolerant to antibiotics.

But macrophages running on glycolysis behaved like warriors. These cells produced bursts of mitochondrial reactive oxygen species (ROS) through a process called reverse electron transport. The ROS flooded the bacteria with oxidative stress, weakening them. In glycolytic macrophages, Mtb became more vulnerable to antibiotics and far easier to kill.

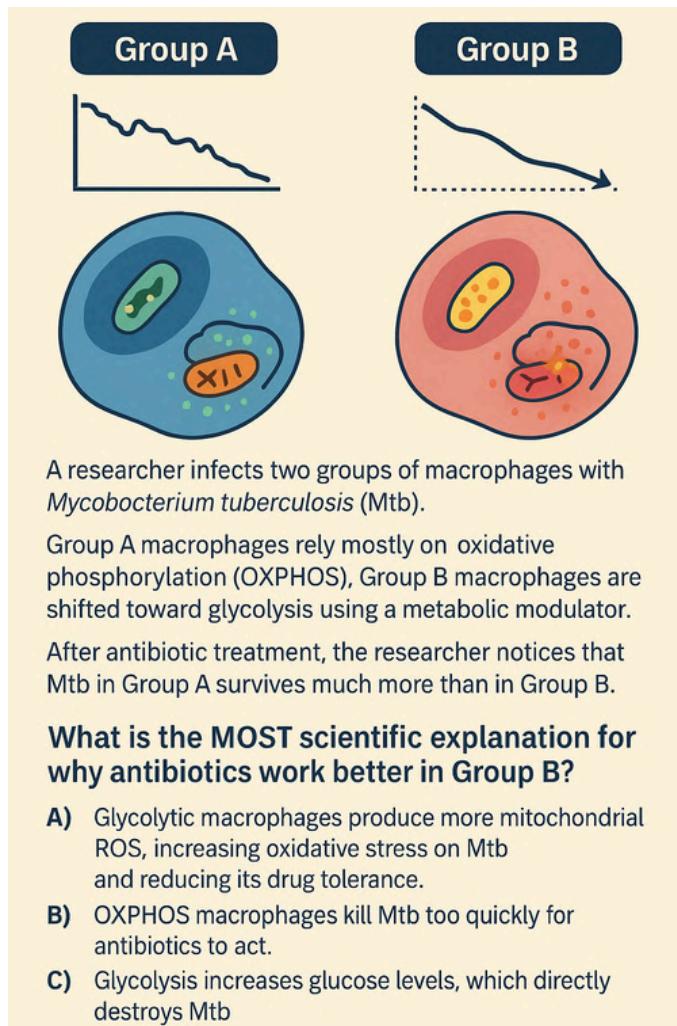
Ishaan was stunned. It wasn't only the bacterium's genetics driving drug tolerance the immune cell's bioenergetic program was shaping the outcome. To understand what controlled this metabolic "switch," the team used transcriptomics, genetic knockdowns, and computational modeling. All evidence pointed toward a master regulator called NRF2, a transcription factor that manages antioxidant responses in the host cell. NRF2 linked macrophage metabolism to the redox state inside Mtb.

If they could manipulate this metabolic switch, they might eliminate drug-tolerant bacteria. Then came the breakthrough. A junior scientist mentioned Meclizine, an FDA-approved drug best known for treating motion sickness. Oddly enough, Meclizine was known to shift cells from OXPHOS toward glycolysis. The idea was unconventional, but Ishaan decided to test it. The results were astonishing. When infected macrophages were treated with Meclizine, the cells quickly switched to glycolysis. Inside them, Mtb experienced higher oxidative stress and became far less tolerant to antibiotics. The glowing reporter inside the bacteria confirmed it their redox heterogeneity dropped sharply. In other words, the bacteria lost their protective "shield."

Encouraged, the team tested Meclizine in mice infected with TB. The treatment worked. Meclizine did not interfere with standard TB drugs and even enhanced their effectiveness by weakening the bacteria inside macrophages. The mice showed clear improvements, and the drug appeared both safe and beneficial in combination therapy.

Standing in the animal facility hallway, Ishaan felt something he hadn't felt in years hope. They had not discovered a new antibiotic; they had discovered a way to help the immune cell fight better.

By flipping a metabolic switch inside macrophages, they could make stubborn Mtb bacteria sensitive again. The implications were enormous: shorter treatments, fewer relapses, and a powerful new strategy against drug-tolerant TB.



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By Mrinal Kashyap

## A NEW FUTURE FOR INDIA'S COAST

The sun had just risen over the quiet shoreline of Puducherry when Meera, a young coastal planner, walked toward the waves with her notebook. She loved this coast the fishermen launching their boats at dawn, the children running along the shore, the mangroves swaying gently in the breeze. But today, she felt a heaviness. The coast was changing too fast. There were more tourists, more boats, more construction, and more pressure on the ecosystems that had protected this community for generations, creating a growing sense of urgency in her mind.

Meera had been assigned to a very important mission: to help design India's first full marine spatial plan for the region. Many countries around the world were already using something called Marine Spatial Planning (MSP) a method to divide marine and coastal spaces into clear zones for fishing, tourism, shipping, conservation, and development. It helped reduce conflicts, protect ecosystems, and support local livelihoods. But in India, MSP was still new and barely implemented.



Her team wanted to change that.

As Meera walked, she noticed a fisherman named Ravi spreading his net. She remembered his complaint from the previous week: "The tourist boats come too close. The fish are moving away. The sea is no longer ours." And then there were tourism operators worried that fishing nets scared away visitors. Conservationists were demanding protection for coral patches and turtle nesting areas. The port authorities wanted room to expand shipping lanes. Everyone wanted something from the same ocean, and the conflicts were growing.

This was exactly why India needed MSP.



Meera's notebook outlined a seven-step framework her team had developed, tailored specifically for Indian regions. First, they had to bring all stakeholders together fishers, tourism groups, conservation experts, port officials, community leaders, and government bodies. Only

| By **Mrinal Kashyap**

by listening to everyone could they create a shared vision for the future. Then came data collection: maps of coral reefs, fish breeding zones, mangroves, turtle nesting beaches, sea-floor types, shipping routes, areas threatened by climate change, and many socio-economic details.

The next step was to analyze how these uses overlapped or conflicted. Only after understanding all this could they draft India's first detailed marine spatial plan a plan that would identify conservation areas, fishing zones, aquaculture zones, shipping corridors, recreation areas, and even cable or pipeline routes.

Puducherry became the pilot site because it captured the reality of India's coast in one small region. It had beautiful ecosystems like mangroves, corals, and turtle nesting grounds. It also had heavy human pressure tourism, ports, fishing villages, and growing urbanization.

By 2022, Meera's team had begun consultations. By 2024, they finally prepared a zoning plan. But the most exciting part was something new: a digital tool called SAHAV, a web-based GIS dashboard. Anyone fishers, officials, researchers, communities could see maps, zones, ecological data, and implementation updates. The tool was even recognized as a Digital Public Good, meaning it promoted open, transparent, and science-based decision-making.

As Meera stood watching the waves, she imagined the future. A future where fishermen like Ravi had secure fishing zones with less conflict. Where tourist boats followed designated paths, reducing disturbances. Where coral reefs and mangroves were mapped, monitored, and protected. Where climate change risks were considered, and plans were adaptable able to evolve as the environment changed.

But she also knew the challenges. India's long coastline brought immense diversity different states, different rules, different cultural practices. Data was incomplete in many areas. Governance was complicated, with overlapping responsibilities between state and central agencies. And balancing economic growth with ecological protection would always be delicate. Still, the Puducherry pilot gave hope. It proved that with the right framework, inclusive participation, good data, and transparent tools like SAHAV, marine spatial planning could work in India.

As she closed her notebook, Meera smiled. The ocean might be full of competing demands, but with careful planning, India could build a resilient and inclusive blue economy one where nature and people thrived together. And Puducherry was the first step in that journey.



One morning in Puducherry, fishermen notice that tourist boats are repeatedly entering their traditional fishing grounds, scaring away fish. At the same time, conservationists are upset that some parts of coral reef are being damaged by the anchors of small boats. Port authorities argue that cargo ships need more navigation space.

A community meeting is called. Meera, the marine planner, brings a map showing potential zones for fishing, tourism, and conservation. Everyone looks frustrated but wants a solution?

- A) Immediately divide the sea into zones and announce rules without consulting anyone
- B) Collect satellite data and maps only, and design the plan based on them.
- C) Bring all stakeholders—fishers, tourism operators, conservation groups, port officials—together to understand their needs and agree on a shared vision.

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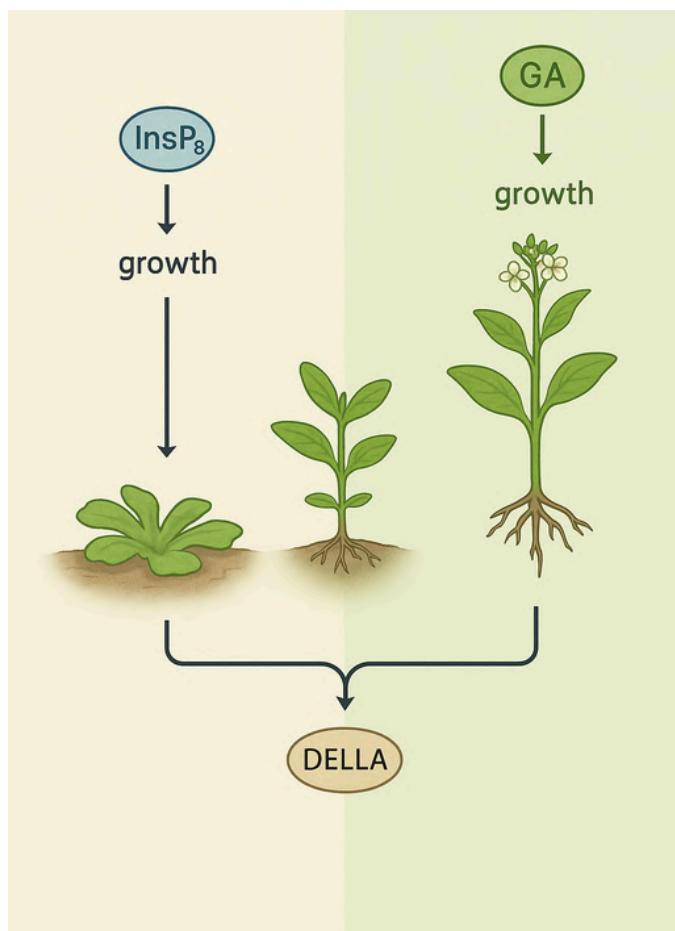
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| By Dr. Manas Ranjan Prusty

## THE FIRST GROWTH SIGNAL ON LAND

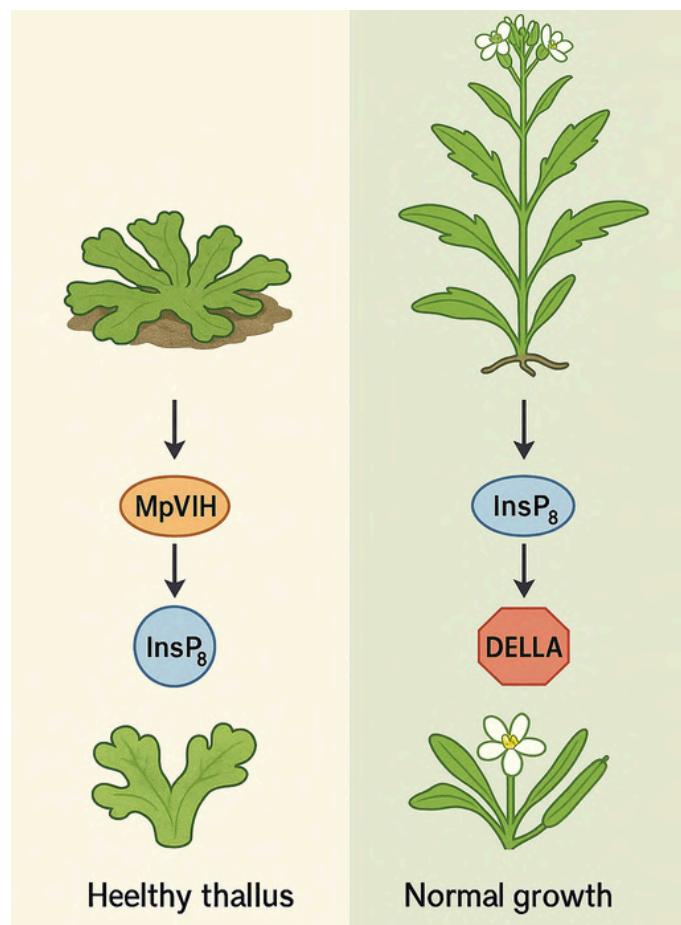
**M**illions of years ago, long before forests, flowers, or crops appeared on Earth, the planet looked completely different. The land was mostly bare rock with patches of wet soil, and almost nothing green grew on it. There were no tall trees for shade, no grass to hold the soil, and no roots to shape the landscape. Into this unpredictable world came one of the first pioneers of land life: a tiny plant called *Marchantia*. Compared to the lush plants we see today, *Marchantia* was incredibly simple. It had no roots, no stems, and no leaves only a delicate flat green sheet hugging the ground. Yet this simple plant carried one of the earliest systems that allowed plants to survive outside water.



Life on land was difficult and full of surprises. The sun's light was harsh and could dry tissues quickly. Water was not always available, and rain came unpredictably. Winds could damage delicate structures, and temperatures shifted rapidly. In this environment, *Marchantia* needed a

reliable way to decide when it was safe to grow and when it needed to conserve energy. Growing at the wrong time could be fatal.

Inside its cells lived a protein called DELLA, which acted like a gatekeeper. DELLA slowed growth whenever conditions were risky, preventing the plant from wasting energy when the environment wasn't suitable. In modern plants such as wheat, rice, and *Arabidopsis*, a hormone called gibberellin (GA) tells DELLA to move aside. GA binds to a receptor and signals for DELLA's destruction, allowing plants to grow faster. But *Marchantia* does not have the GA receptor. This created a scientific mystery: if *Marchantia* cannot use GA, how does it regulate DELLA and control growth?



To find the answer, scientists studied another molecule inside the plant an enzyme called MpVIH. This enzyme produces a small chemical messenger named InsP<sub>8</sub>, part of a powerful family of inositol pyrophosphates that help cells sense nutrients, stress, and internal signals. The researchers wondered whether InsP<sub>8</sub> might be the ancient molecule that early land plants used as a "growth-permitting signal," long before modern hormones evolved.

| By Dr. Manas Ranjan Prusty

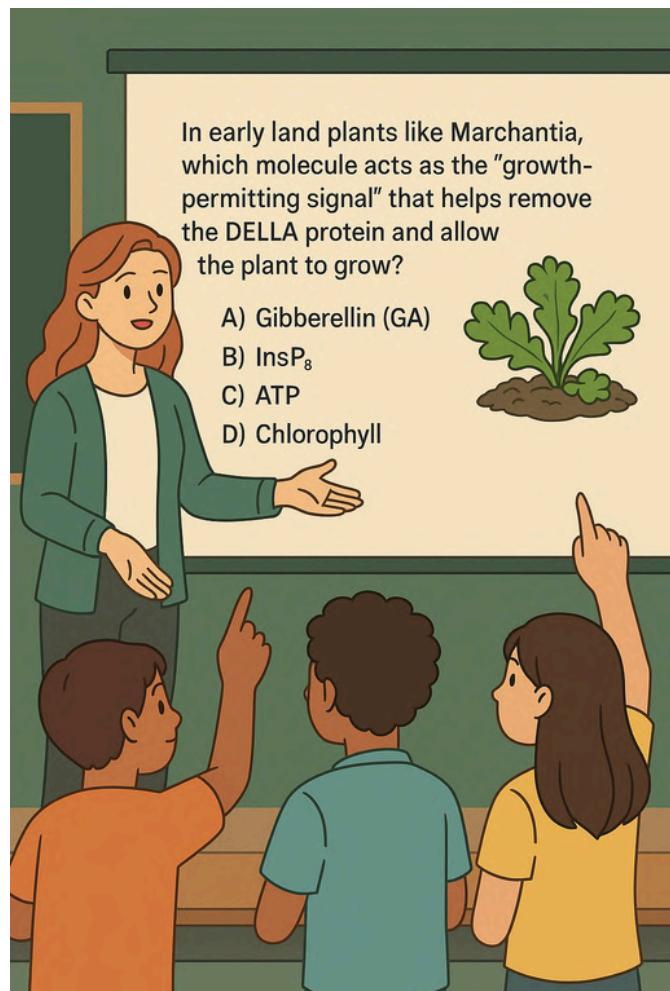
To investigate, they used CRISPR to remove the MpVIH gene from *Marchantia*. The results were dramatic and immediate. Without MpVIH, the plants became extremely small, twisted, and unable to grow outward. The normally smooth fan-shaped thallus became distorted, and the plants failed to form gemma cups, which *Marchantia* needs for reproduction. The growth tips where new cells form became almost inactive. This severe growth arrest looked exactly like plants overwhelmed by too much DELLA, suggesting that InsPs normally helps control DELLA's activity.

The scientists then tested whether InsPs directly interacted with DELLA. Through detailed biochemical experiments, they discovered that InsPs binds very strongly to the DELLA protein. When InsPs attaches to DELLA, it slightly changes the protein's shape. This shape change exposes special positions where small molecular tags called ubiquitin can attach. These ubiquitin tags act like "destroy me" labels that guide DELLA to the cell's recycling center, the proteasome, where it gets broken down. This means that InsPs plays a crucial role by signaling the cell to degrade DELLA so that growth can continue. Without InsPs, DELLA becomes stable, stubborn, and nearly impossible to remove, which prevents the plant from growing.

To confirm their findings, the researchers created a special version of DELLA that cannot bind InsPs. This mutant DELLA was almost indestructible. Plants carrying this version grew even smaller and weaker than those lacking MpVIH, proving that binding to InsPs is essential for DELLA regulation.

Finally, the scientists asked whether this ancient mechanism exists only in *Marchantia* or is shared with modern plants. When they studied *Arabidopsis*, they found that plants unable to produce InsPs accumulated large amounts of DELLA and were severely stunted. Restoring the enzyme responsible for InsPs production restored normal DELLA breakdown and healthy growth.

These discoveries revealed something extraordinary: long before plants evolved the GA hormone system, they already used InsPs as an ancient and fundamental growth signal. This simple molecular communication helped the earliest land plants survive Earth's challenging conditions and eventually led to the incredible diversity of plant life we see today.



Together, these findings position InsPs as a deeply conserved molecular signal that predates classical plant hormones and underpins growth regulation across land plants. By revealing how ancient signaling molecules control protein stability, this work offers new evolutionary insight and opens possibilities for manipulating growth pathways to improve resilience and productivity in modern crops.

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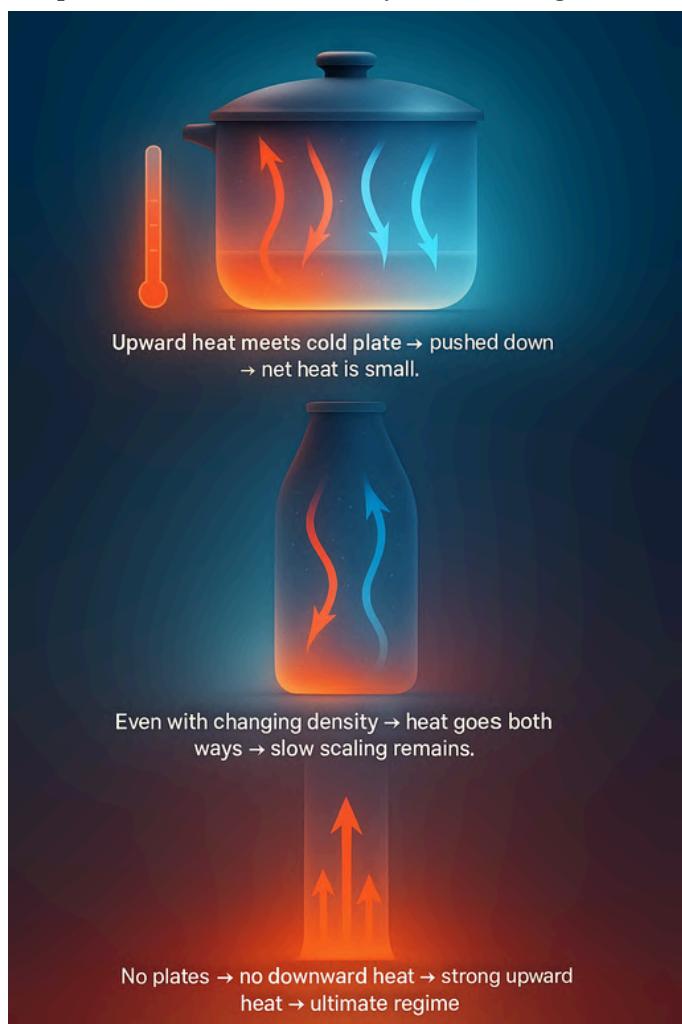
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By Dr. Priyanka

## THE MYSTERY OF THE THREE KETTLES

In the peaceful town of Suryapur, three young Indian scientists Ravi, Nisha, and Tarun loved to solve scientific mysteries. Every evening, they met under a large neem tree near the university and discussed ideas over hot cups of chai.

One question kept returning to their conversations: *How fast can heat move upward in a boiling or very turbulent fluid?* This was not just about boiling water. It mattered for understanding weather, ocean currents, engines, and even the inside of stars. Scientists around the world had debated this problem for decades, but they still did not agree.



To understand this better, Ravi explained two important ideas. The first was the Rayleigh number (Ra), which tells how strong the heating is. The second was the Nusselt number (Nu), which measures how much heat actually travels upward.

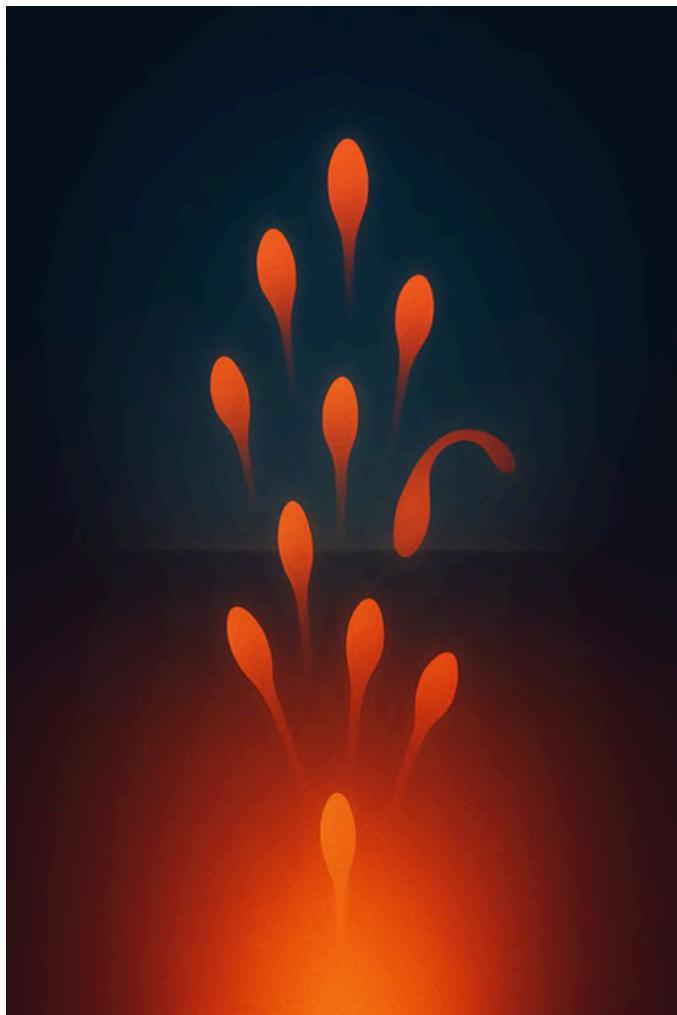
Some scientists believed that when heating becomes extremely strong, fluids enter a special "super-turbulent" state called the ultimate regime, where heat moves very fast. But other scientists argued that this special regime may never show up in real systems. Because the results were mixed and confusing, the three friends decided to investigate the mystery themselves.

Ravi suggested using powerful computer simulations to build "magic kettles" that could show what really happens inside a boiling or turbulent fluid. The first kettle they built was the Plate Kettle, which looked like a simple pot with a hot bottom plate and a cold top plate. This setup is known as Rayleigh–Bénard convection. When they started heating it, hot fluid naturally rose from the bottom, and cold fluid sank from the top. But as the flow became stronger, something unexpected happened. When hot rising plumes reached the cold top plate, they were pushed downward again. This created two kinds of heat motion: positive heat flux (heat going up) and negative heat flux (heat going down).

Nisha measured these carefully and made a surprising discovery. The upward heat and downward heat were almost equal. They cancelled each other so well that only a small amount of heat actually moved upward. Even when they turned the heating to extremely high levels, the total upward heat increased only slowly, following a simple rule:  $\text{Nu} \approx \text{Ra}^{0.30}$ . This is known as the classical scaling. There was no sign of the ultimate regime.

Next, the team built the Star Kettle, where the fluid's density changed with height, similar to what happens inside stars. Although this system behaved differently from the Plate Kettle, the result was almost the same. Hot blobs rose upward but were again pushed downward by the cold upper region. Heat moved in both directions up and down cancelling each other and producing the same slow-growing heat transport. Even in this more realistic, star-like system, the ultimate regime did not appear.

Finally, they built the most interesting one: the Endless Kettle, which had no top plate and no bottom plate. It stretched endlessly, like a fluid without walls. When they heated this kettle, hot fluid rose upward freely. Nothing pushed it down. There was no negative heat flux at all. As a result, heat moved upward continuously and strongly. For the first time, the friends observed the super-fast heat flow



scientists had predicted. This kettle followed the rule  $\text{Nu} \approx \text{Ra}^{0.50}$ , the clear sign of the ultimate regime.

At last, the mystery was solved. The three scientists realized that the plates in real systems were the real reason the ultimate regime never appeared. The plates forced some of the heat to move downward, slowing the total heat transport. Only when the plates were removed did the system reach the ultimate regime. Smiling, Tarun wrote their final conclusion: "In real-world convection, plates act like barriers that slow heat down, while plate-free systems allow heat to race upward freely."

Their discovery brought clarity to a puzzle that had confused scientists for many decades.

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## SITUATION QUIZ

### SITUATION:

Ravi is studying heat movement in a fluid. He notices something unusual: Hot fluid rises from the bottom, but as soon as it reaches the cold top plate, it gets pushed downward again. The upward and downward motions almost cancel each other.

What will happen to the overall heat transport in this situation?



- A Heat transport will become extremely strong (ultimate regime)
- B Heat transport will remain slow because upward and downward heat cancel
- C Heat will only move downward
- D Heat transport will stop completely

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## UNDERSTANDING ARTIFICIAL INTELLIGENCE

1. What does AI stand for?

- A. Automated Information
- B. Artificial Intelligence
- C. Advanced Internet
- D. Applied Innovation

2. Which of these is an example of AI?

- A. Calculator
- B. Washing machine
- C. Voice assistant (like Siri or Alexa)
- D. Electric fan

3. What is the main goal of Artificial Intelligence?

- A. To replace humans
- B. To make machines think and learn like humans
- C. To make machines faster
- D. To store more data

4. Which device uses AI to recognize your face?

- A. Radio
- B. Smartphone
- C. Torch
- D. Keyboard

5. AI learns from which of the following?

- A. Electricity
- B. Data
- C. Wires
- D. Batteries

6. Which of these is NOT an AI application?

- A. Self-driving car
- B. Recommendation systems (YouTube, Netflix)
- C. Typewriter
- D. Chatbots

7. What is Machine Learning?

- A. Teaching machines by hand
- B. Machines learning from data and experience
- C. Machines repairing themselves
- D. Machines using the internet

8. What is a chatbot?

- A. A robot dog
- B. A computer program that talks like a human
- C. A video game
- D. A search engine

9. AI systems can be trained to:

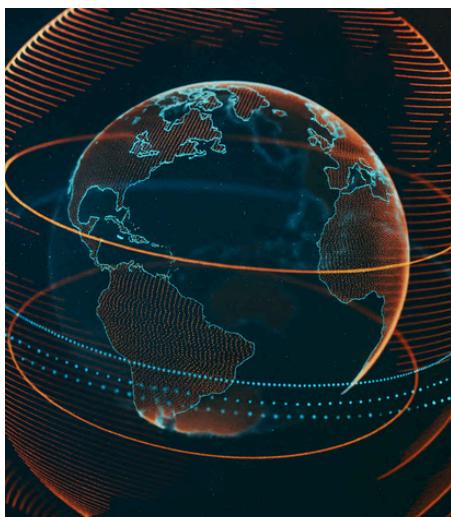
- A. Feel emotions
- B. Learn patterns and make decisions
- C. Sleep
- D. Grow

10. What is a risk of using AI?

- A. Loss of electricity
- B. Data privacy and misuse
- C. Slower computers
- D. Less internet

## DISCOVERY HIGHLIGHTS

### CLIMATE SCIENCE & EARTH SYSTEMS



#### INDIA'S 84-YEAR RAINFALL MYSTERY FINALLY UNLOCKED

For decades, scientists have struggled to answer a simple question: *How exactly does moisture travel through India's atmosphere to make the monsoon so powerful yet so unpredictable?* A new discovery has changed that. Researchers have built an extraordinary dataset that tracks atmospheric moisture hour by hour, from 1940 to 2024, across all of India. It acts like a time-machine for the sky. This dataset, called ERA5moistIN, reveals how winds carry water, how moisture converges to form rain, and how the atmosphere stores and releases water across seasons. Scientists validated the system against known ERA5 measurements, confirming its accuracy. This breakthrough could transform monsoon research, improve flood and drought prediction, and strengthen early-warning systems. For the first time, we can watch India's atmospheric water cycle evolve over 84 years with incredible detail.

*Raghuvanshi AS, Scientific Data, Nov 2025*

### HOW POLLUTION IS SECRETLY HEATING THE CENTRAL HIMALAYAS

Why are Himalayan glaciers melting faster than expected even in places far from cities?

A new study uncovers a hidden culprit: invisible heat-absorbing particles rising deep into the mountains. Scientists measured aerosols like black carbon, organic carbon, and dust at different altitudes across the Central Himalayas and made a surprising discovery: pollution isn't just near the ground. It rises more than 5 km into the atmosphere, where glaciers live. Black carbon, produced from vehicles and burning, absorbs sunlight and heats the air. The study found that at some locations, more than 50% of aerosol absorption came from black carbon alone especially before the monsoon. Even high mountain stations showed significant heating. These warm layers disrupt snowfall, accelerate glacier melt, and may alter future monsoon circulation. The findings highlight an urgent need for cross-border pollution control.

*Singh PK, Science of the Total Environment, Nov 2025.*

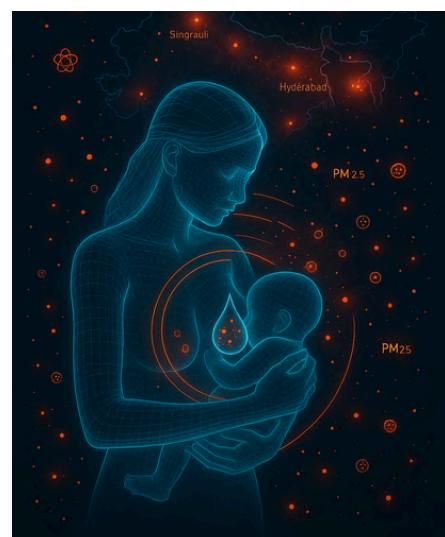
### PUBLIC HEALTH & DISEASE RISKS

#### URANIUM IN BREASTMILK : A HIDDEN THREAT REVEALED IN BIHAR

What if something as natural and nourishing as breastmilk carried a silent danger? Researchers in Bihar made a startling discovery: every single breastmilk sample they tested contained uranium (U-238). Even more worrying, infants showed far higher health risks than their mothers because their bodies cannot

eliminate uranium efficiently. About 70% of the infants in the study were exposed to uranium levels capable of causing non-cancer health effects, especially kidney damage. One district—Katihar—had the highest contamination. This work exposes a hidden pathway of uranium exposure that had never been systematically measured before: contaminated groundwater → mothers → infants. The findings raise an urgent alarm for biomonitoring and clean-water interventions. What appears harmless on the surface may carry long-term danger for the next generation.

*Kumar A., Scientific Reports, Nov 2025.*



#### INDIA'S AIR: WHEN PLASTIC BECOMES SOMETHING YOU BREATHE

Imagine taking a deep breath in a crowded marketplace without realizing you've inhaled tiny plastic particles small enough to enter your lungs. A groundbreaking study across four major Indian cities detected inhalable microplastics (iMPs <10 µm) at human breathing height. Winter evenings in Kolkata and Delhi showed the highest levels, driven by

dense crowds, synthetic clothing, and poor waste handling. These plastics don't just enter the air they act as carriers for toxins and microbes. Researchers found that iMPs were transporting lead, phthalates, pathogenic fungi like Aspergillus, and even antibiotic-resistant bacteria. Over a lifetime, an average Indian city resident may inhale nearly 3 grams of plastic. This discovery reveals a new kind of pollution one that is invisible, inhalable, and biologically dangerous. Breathing air is no longer just breathing air.

*Biswas A., Environment International, Nov 2025.*

## MEDICAL RESEARCH & IMMUNOLOGY



### WHY SOME COVID-19 VIRUSES ESCAPE EVEN STRONG ANTIBODIES

Scientists have found something surprising about the SARS-CoV-2 spike protein, the main target of vaccines and antibodies. Even when powerful antibodies attack the virus, a tiny fraction of viruses survive. But why? Researchers discovered a hidden

group of viral particles called the Persistent Fraction (PF). These viruses aren't mutants; instead, their spike proteins fold differently and carry more sugar-like coatings (mannosidic glycans). This makes them harder for antibodies to grab. PF viruses also have their spike cut more sharply at a specific point (the S1-S2 site), which locks them in a closed shape that antibodies struggle to neutralize. This discovery suggests that even without mutations, the virus has clever structural tricks to evade immunity helping explain breakthrough infections.

*Kumar S., Nature Communications, Nov 2025.*

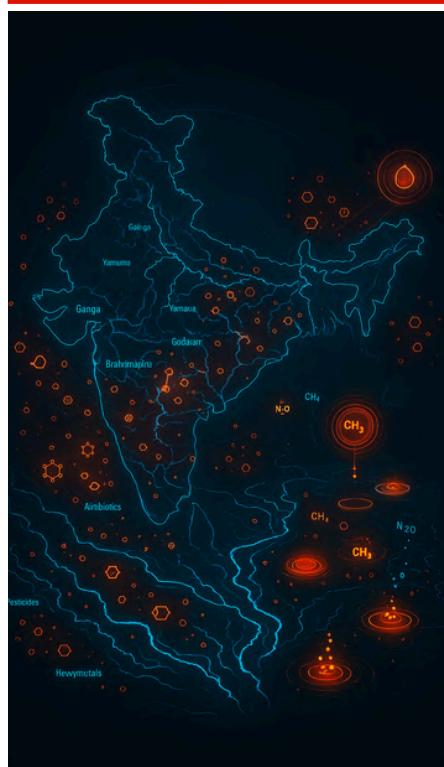
### A BLOOD TEST THAT PREDICTS WHO WILL DEVELOP TUBERCULOSIS

Millions carry the TB bacterium silently but only some develop active disease. What if we could predict who is at greatest risk before they fall sick? Scientists followed healthy household contacts of TB patients for two years. Some eventually developed TB; others stayed healthy. By analyzing hundreds of small molecules (metabolites) in their blood, researchers discovered a set of "warning signals." Two molecules Malic acid and N-Arachidonoylglycine almost perfectly predicted who would progress to TB. Other molecules linked to fat and nitric-oxide pathways also shifted dramatically in high-risk individuals.

This breakthrough could lead to a simple test that identifies people who need preventive treatment, helping stop TB before it starts.

*Daniel E.A., Emerging Microbes & Infections, Dec 2025.*

## MICROBIOLOGY & ECOSYSTEM HEALTH



### TOXIC FOOTPRINTS: HIDDEN CHEMICAL CONTAMINATION IN INDIA'S RIVERS & WETLANDS

India's freshwater ecosystems may look clean on the surface, but a nationwide investigation has revealed an invisible cocktail of endocrine-disrupting chemicals spreading through rivers, reservoirs, floodplains, and sewage-fed wetlands. Scientists tested water and fish for phenolic contaminants like triclosan (TCS), triclocarban (TCC), and methyl-triclosan (MetCS). The shocker? Fish in the Cauvery carried contaminants even when the water showed zero detectable levels, proving that pollutants accumulate silently in the food chain. In Kolkata's sewage-fed wetlands, over 80% of water samples contained TCS, while

## DISCOVERY HIGHLIGHTS

floodplain wetlands showed contamination only in fish revealing invisible bioaccumulation pathways. These chemicals are linked to early puberty, hormonal disruption, and ecosystem damage. This first-of-its-kind nationwide dataset exposes a hidden toxic burden and highlights the urgent need for upgraded wastewater treatment and targeted chemical regulations.

*Das Sarkar et al., Science of the Total Environment, Nov 2025.*

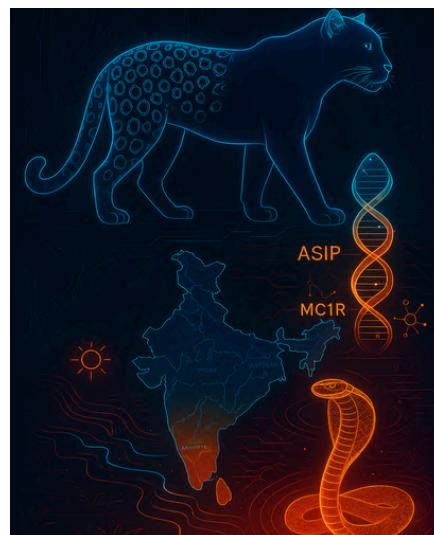
### AQUACULTURE PONDS: INDIA'S HIDDEN GREENHOUSE GAS FACTORIES

You might imagine fish farms as quiet, climate-friendly food systems but a new study shows they can be powerful emitters of greenhouse gases. Researchers measured methane and carbon dioxide bubbling out of freshwater aquaculture ponds across tropical India and found something startling: aquaculture ponds emitted over 20 times more methane than nearby natural ponds. Methane is a climate super-pollutant, and here it was fueled by a mix of fish feed, dense stocking, rich organic matter, and warm stagnant water.

Land-use change also played a role. As farms replace wetlands and vegetation, carbon-rich sediments create ideal conditions for methanogenesis. The study warns that the rapid expansion of unregulated aquaculture could silently amplify India's climate footprint. Smarter pond design, vegetation buffers, and feed optimization could drastically cut emissions and protect natural carbon cycles.

*Bera et al., Environmental Pollution, Nov 2025.*

### WILDLIFE & EVOLUTION



### WHY SOME LEOPARDS TURN COMPLETELY BLACK

Some Indian leopards carry a stunning secret in their DNA, a tiny mutation that turns their golden coats jet black. Scientists studying leopard genomes discovered a single change in the agouti signalling protein (ASIP) gene, called p.C117F, that switches the animal's colour program completely. This mutation weakens ASIP's ability to stop the MC1R receptor from making dark pigment, so black fur spreads across the entire body. Computer simulations revealed that this altered protein becomes unstable and binds poorly to its partner receptor, making the "black mode" stay turned on permanently. Evolutionary analysis also suggests this mutation may have been favoured in dense forests, where darker coats offer better camouflage. This is the clearest evidence yet that one tiny genetic change can reshape an entire wild animal's appearance and possibly its survival strategy.

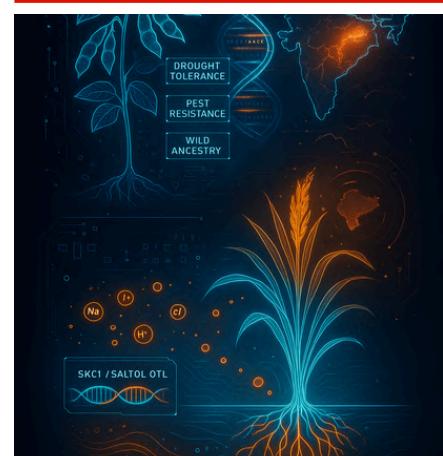
*Ghosh et al., BMC Genomics, Nov 2025.*

### CLIMATE CHANGE IS PUSHING VENOMOUS SNAKES INTO NEW REGIONS

India's venomous snakes are on the move and climate change is steering their path. A new nationwide modelling study used thousands of snake sightings and climate predictions to map how species like cobras, kraits, Russell's vipers, and saw-scaled vipers will shift their habitats by 2050 and 2070. The results are striking: several traditional snake hotspots in the Western Ghats and Northeast may shrink, while new high-risk zones emerge in the Himalayas, central India, and plateau regions. As temperatures warm and rainfall patterns change, snakes are likely to expand into regions that previously had low danger. The study also shows that areas predicted to become more suitable for snakes already report higher snakebite cases a worrying sign for the future. This work offers an early warning system for public health and conservation planning before snakebite risks rise further.

*Khandve et al., Scientific Reports, Nov 2025.*

### AGRICULTURE & PLANT GENOMICS



## WILD PIGEONPEA GENOME DISCOVERY

Scientists have finally uncovered the secret behind the incredible toughness of a wild pigeonpea species, *Cajanus platycarpus*. Unlike cultivated pigeonpea, which suffers badly from pests and drought, this wild relative carries a powerful genetic toolkit that helps it survive almost anything. When researchers sequenced its genome at high resolution, they found something remarkable: more than 12,700 duplicated genes, many involved in plant defence and stress response. These extra gene copies act like backup strength, allowing the plant to react faster and harder to threats. They also discovered major changes in regulatory DNA and unique versions of pest-recognition genes, explaining why this wild species can easily detect and fight off insects like *Helicoverpa*. This genomic treasure chest could help scientists breed stronger, climate-resilient pigeonpea varieties for the future.

*Rathinam et al., Journal of Experimental Botany, Nov 2025.*

## WHY SOME RICE SURVIVE SALTY FLOODS

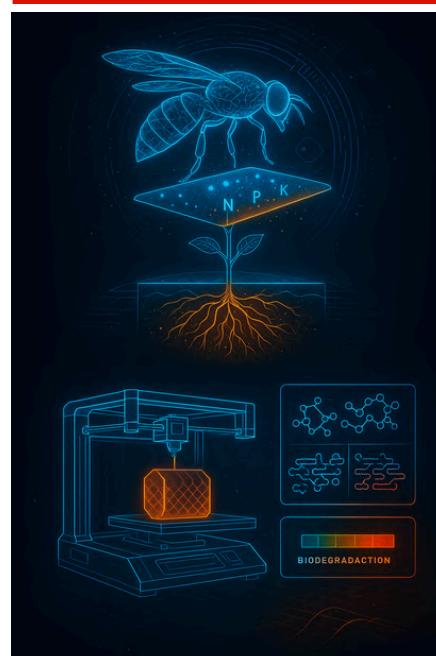
### WILD PIGEONPEA GENOME DISCOVERY

Rice growing in coastal regions often faces a deadly combination: saltwater and flooding at the same time. Most plants cannot survive this double stress, but scientists discovered why some special rice lines can. In a controlled experiment, researchers compared rice containing the *Sub1* gene (flood-tolerant) and *Saltol* (salt-tolerant). Surprisingly, *Sub1* rice survived far better under “saline submergence.” Why? These plants switch to an “energy-saving mode” and

form a thick leaf gas film that stays underwater, delaying salt entry for hours. *Saltol* plants tried to fight salt actively, an energy-heavy strategy that caused them to quickly burn through their carbohydrate reserves and die. This study shows that during salty floods, conserving energy beats resisting salt, revealing a powerful mechanism that breeders can use to protect rice in climate-vulnerable regions.

*Chakraborty et al., Journal of Experimental Botany, Nov 2025.*

## CHEMISTRY & CLEAN ENERGY



### TURNING INSECT WASTE INTO A SMART, SELF-FERTILIZING MATERIAL

What if something as simple as insect shells could solve two global problems at once polluted water and expensive fertilizers? In this remarkable discovery, scientists transformed discarded black soldier fly exuviae into a biodegradable sponge-like material that captures

phosphate from wastewater and then slowly releases it to crops. The secret lies in a clever combination of chitosan, CMC, and iron oxide nanoparticles that grab phosphate through strong chemical bonding. Even more exciting, this eco-material holds 35 times its weight in water and biodegrades naturally in soil within 90 days. Once full of nutrients, it becomes a “smart fertilizer,” feeding plants gradually and as effectively as commercial fertilizers while also supplying nitrogen from chitosan itself. This circular innovation turns waste into a powerful tool for sustainability, helping clean water while boosting agriculture in a single elegant solution.

*E. P. et al., Environmental Research, Nov 2025*

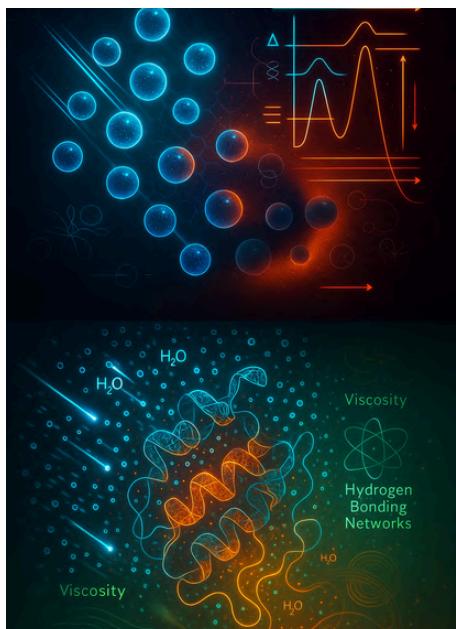
## A HIDDEN PROBLEM WITH SUSTAINABLE PLASTICS: 3D PRINTING MAKES THEM LESS BIODEGRADABLE

Bioplastics like PHB are often promoted as the future of eco-friendly manufacturing but a surprising new finding reveals a hidden twist. When PHB is processed through 3D printing (FDM), it becomes less biodegradable than the original filament. Why? The intense heat and extrusion force during printing reorganize the polymer chains, increasing crystallinity from 40% to over 60%. These tightly packed regions act like armor, preventing microbes and water from breaking the material down efficiently. In biodegradation tests mimicking anaerobic landfill conditions, printed sheets produced 10% less methane and degraded 8% slower than untreated filament. This discovery is crucial: not all bioplastics

remain “green” once processed. Designers and manufacturers must now rethink print settings and polymer formulations to ensure that sustainability doesn’t get lost in the manufacturing step.

*Jena A. et al., Science of the Total Environment, Nov 2025*

### ADVANCED MATERIALS & QUANTUM SCIENCE



### WHY CARBON DOTS LOSE THEIR GLOW A HIDDEN LIGHT-TRAP MECHANISM

Scientists studying carbon dots tiny glowing nanoparticles have uncovered a surprising reason why these materials suddenly lose brightness at high concentrations. Until now, researchers believed that the dimming happened because the particles clumped together. But this study shows a completely different culprit: photon reabsorption. When carbon dots emit light, some of that light gets re-absorbed by other carbon dots before it can escape, creating a misleading redshift and reduced intensity. Using depth-dependent

photoluminescence and time-resolved measurements, the researchers proved that the particles were not aggregating; instead, they were trapping and recycling their own light. This breakthrough changes how scientists interpret optical signals from carbon dots and similar nanomaterials. It also helps engineers design brighter, more reliable sensors, LEDs, biomedical markers, and quantum-dot technologies.

*Devan CM et al., Spectrochimica Acta Part A, Nov 2025.*

### HOW WATER'S MOVEMENTS DECIDE PROTEIN STABILITY IN GREEN SOLVENTS

Proteins behave strangely in “deep eutectic solvents,” a new class of eco-friendly liquids used for green chemistry and biocatalysis. But until now, nobody understood why certain proteins become more or less stable in these unusual environments. This study reveals a fascinating answer: it all depends on how water molecules move around the protein. Using advanced fluorescence techniques and structural analyses, scientists discovered that flexible water boosts stability through enthalpy, while restricted water boosts stability through entropy opposite mechanisms that balance each other. This dynamic “push-and-pull” controls how proteins fold, function, and survive in industrial or medical applications. The findings offer a powerful blueprint for designing better solvents for drug formulation, enzyme engineering, and sustainable bioprocessing.

*Khan T et al., Biophysical Journal, Dec 2025.*

### TECH & ARTIFICIAL INTELLIGENCE



### AI LEARNS TO SEGMENT MEDICAL IMAGES FASTER THAN TRANSFORMERS

Medical AI is getting smarter and lighter. In hospitals with limited computing power, running massive Vision Transformers (ViTs) for image segmentation is difficult. A new model fixes this problem: U-VixLSTM, which blends CNNs with a special Vision-xLSTM module that captures long-range patterns without heavy computation. This model understands both the local textures and global shapes inside medical scans. When tested on major public datasets such as Synapse, ISIC, and ACDC, U-VixLSTM outperformed even state-of-the-art transformer-based systems but using a fraction of the computational cost. That means radiology units in smaller hospitals, remote clinics, and mobile diagnostic vans could run powerful segmentation tools without needing huge GPUs. This study pushes AI one step closer to globally accessible healthcare. *Dutta et al., Neural Networks, Dec 2025.*

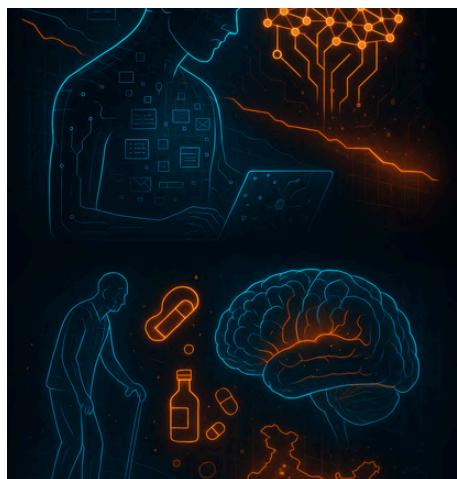
## DISCOVERY HIGHLIGHTS

### AI FORECASTS MALARIA OUTBREAKS WEEKS AHEAD

Controlling malaria remains one of India's toughest health challenges. But scientists have now created an AI-assisted forecasting system that predicts malaria cases state-by-state across India. Using advanced time-series models including log-polynomial regression, ARIMA, and lag-difference models, the researchers analyzed years of malaria data from eight states. The surprising finding: a simple-looking model, log-transformed polynomial regression, beat every other approach in accuracy and consistency. The team then built an interactive R-Shiny dashboard where health departments can upload their data and instantly receive short-term malaria forecasts, confidence intervals, and model comparisons. With this tool, officials can pre-position medicines, target high-risk districts, and respond faster than before. This project shows how statistical AI can transform disease surveillance without needing deep learning.

*Ghosh et al., Malaria Journal, Nov 2025.*

### SOCIAL SCIENCES, AI & HUMAN BEHAVIOUR



### AI JOB LOSS ISN'T JUST A CAREER SHOCK IT REWRITES A PERSON'S IDENTITY

A new qualitative study reveals the hidden emotional toll when Indian IT professionals lose their jobs to AI automation. Through in-depth interviews and expert validation, researchers found that job displacement triggers a deep psychological rupture not just economic anxiety. People describe an initial wave of disbelief, followed by a painful erosion of identity as roles they spent years mastering suddenly become irrelevant. Many withdraw socially, struggle with chronic fear about the future, and experience a profound sense of organizational betrayal. Others try to rebuild through coping strategies, though not always healthy ones. This study shows that AI-driven job loss is not merely a technology story, but a mental health crisis emerging in India's largest knowledge sector one that urgently requires compassionate policy, counselling support, and organizational preparedness.

*Sharma V. Int'l J Qualitative Studies on Health & Well-Being, Nov 2025.*

### WHY SUBSTANCE USE QUIETLY ACCELERATES COGNITIVE DECLINE IN INDIA'S ELDERLY

A large national dataset reveals a concerning pattern: alcohol and tobacco use significantly raise the odds of cognitive impairment among India's older adults. More than 10% of elders already show signs of memory and thinking decline and lifestyle habits accelerate the risk. Alcohol users were 17% more likely to experience cognitive impairment, while smokers showed elevated risk as well. The study connects these

behaviours to long-term brain health damage, layering over socioeconomic vulnerabilities and chronic disease.

The findings highlight an urgent public health need: screening older adults who consume alcohol or tobacco before symptoms worsen. Early detection could delay dementia progression, improve quality of life, and reduce healthcare burden aligning directly with India's Sustainable Development Goal 3 of promoting well-being at all ages.

*Ali A. BMC Geriatrics, Nov 2025.*

### AI IS NOT A SUBSTITUTE FOR HUMAN INTELLIGENCE

In *Nature Reviews Psychology* emphasizes that artificial intelligence should be viewed as a complement to human intelligence rather than a replacement. As AI tools such as large language models become increasingly embedded in daily life, psychologists stress that humans and AI bring distinct strengths to decision-making. Humans excel at understanding emotions, ethics, and social context, while AI is effective at processing large datasets and supporting complex analyses.

The article highlights growing evidence that human-AI collaboration can improve outcomes in areas such as disaster response and mental health care. However, it also warns of risks, including bias, reduced fairness, and loss of human autonomy if AI systems are used without proper oversight. Responsible integration, transparency, and psychological insight are therefore essential to ensure AI enhances, rather than undermines, human behaviour and decision-making.

*Nature Reviews Psychology, Dec (2025).*

## SCIENCE IN FOCUS

In December 2025, the Indian Institute of Astrophysics (IIA) marked an important milestone 10 successful years of the Ultraviolet Imaging Telescope (UVIT) operating in space aboard AstroSat. UVIT opened its doors to the universe on 30 November 2015, soon after AstroSat was launched by ISRO on 28 September 2015. AstroSat is India's first dedicated space observatory and can observe the universe across a wide range of light, from ultraviolet to X-rays.

UVIT is the primary ultraviolet instrument on AstroSat. Because Earth's atmosphere blocks ultraviolet (UV) light, UV observations are only possible from space. UVIT is India's first UV space telescope and, apart from the Hubble Space Telescope, it is currently the only operational telescope capable of observing in the far-ultraviolet region.

The telescope was fully designed, assembled, tested, and delivered by IIA from its Hosakote campus near Bengaluru. To celebrate its 10-year journey and to discuss future UV missions, IIA organised a one-day academic workshop on 4 December 2025, bringing together scientists who contributed to the mission.

UVIT consists of two co-aligned telescopes. One observes near-ultraviolet and visible light, while the other observes far-ultraviolet light. Its unique strength lies in combining a large field of view with very sharp images, achieving a spatial resolution better than 1.5 arcseconds better than earlier UV missions such as NASA's GALEX.

Over the past decade, UVIT has made many important discoveries. It has helped identify hot companion stars in stellar systems, studied star formation around active galactic nuclei, observed novae in the Andromeda galaxy, discovered extended ultraviolet disks in dwarf galaxies, and detected ultraviolet emission from very distant galaxies. UVIT has also revealed links between ultraviolet and X-ray radiation in active galaxies and provided new insights into how young stars form in galaxies.

UVIT's success was possible through a national and international collaboration led by IIA, with contributions from IUCAA, TIFR, multiple ISRO centres, and the Canadian Space Agency. Since launch, the UVIT Payload Operation Centre at IIA has been producing science-ready



## India's Ultraviolet Eye in Space: 10 Years of UVIT on AstroSat

data for astronomers worldwide.

In 10 years, UVIT has observed 1,451 celestial targets, contributed to about 300 research papers, and supported 19 PhD theses. Its data are now archived at ISRO's ISSDC for future research. Building on this success, scientists are now planning a next-generation mission called INSIST, which aims to take India's ultraviolet astronomy even further.

Beyond its scientific output, UVIT has also played a vital role in building India's expertise in space instrumentation, data processing, and mission operations. It has trained a new generation of astronomers and engineers while demonstrating India's capability to design and operate world-class space telescopes. As plans for INSIST take shape, UVIT stands as a powerful reminder that sustained investment in scientific infrastructure can deliver long-lasting impact, inspire collaboration, and keep India at the forefront of global space science.

### REFERENCE

Indian Space Research Organisation (ISRO). "Celebrating a Decade of India's first Astronomy Observatory AstroSat"..  
[isro.gov.in](http://isro.gov.in)

SCIENCE IN FOCUS

Gene editing has already begun transforming agriculture, medicine, and biotechnology. But until now, most advanced tools like CRISPR-Cas9 were developed abroad, requiring expensive licensing and facing intellectual-property restrictions. That's why the recent announcement from the Indian Council of Agricultural Research (ICAR) is so significant: India has developed its own compact gene-editing tool, based on an enzyme called TnpB.

This new tool works like molecular scissors, capable of cutting DNA at precisely chosen locations. But unlike the larger Cas9 protein, TnpB is much smaller and easier to deliver into plant cells. This makes the editing process simpler, more efficient, and potentially capable of bypassing difficult tissue culture steps. For crop scientists, this is revolutionary.

Why does this matter for India? Because agriculture here faces enormous challenges heat waves, droughts, declining soil fertility, new pests, and changing rainfall patterns. Gene editing allows scientists to create crops with improved yield, stronger disease resistance, and better climate resilience. Having a home-grown tool means Indian labs can innovate without relying on foreign patents, reducing costs and speeding up development.

ICAR's TnpB-based system could help accelerate the breeding of improved rice, wheat, maize, pulses, millets, and horticultural crops. It could also support the revival of underutilized "orphan crops" such as millets and indigenous legumes, which are crucial for nutrition and climate adaptation.

Another advantage is accessibility. Smaller institutions and state agricultural universities often cannot afford the high-cost licensing of foreign genome-editing systems. A domestic, openly accessible tool democratizes innovation, allowing more researchers across India to participate.

Importantly, this advance aligns with India's evolving regulatory landscape, which already provides a simplified pathway for non-transgenic gene-edited crops. This means crops edited with ICAR's tool may reach farmers more quickly than traditional genetically modified varieties.

ICAR's discovery symbolizes scientific self-reliance: an advanced technology built for Indian challenges, by Indian



**ICAR's New Gene-Editing Tool:  
India's Home-Grown Answer to  
CRISPR**

scientists. It promises faster development of climate-smart crops, reduced dependence on foreign technologies, and a new era of innovation in Indian agriculture.

In the coming years, this tool may become as iconic as CRISPR itself especially if it helps secure food for millions in a warming world.

Beyond agriculture, ICAR's TnpB-based gene-editing system also opens doors for future applications in plant-microbe interactions, biofortification, and sustainable input reduction. As researchers begin to adapt and refine this tool, its success could inspire further indigenous innovation in genome engineering. More broadly, it signals a shift from technology adoption to technology leadership, positioning India not only as a user of cutting-edge biotechnology but as a global contributor shaping its direction.

**REFERENCE**

"Patent for a Next-Generation Genome Editing tool granted to ICAR-NRRI," ICAR — Central Rice Research Institute (CRRI), 2025. [icar.org.in](http://icar.org.in)

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## SCIENCE IN FOCUS

In December 2025, NITI Aayog released a national roadmap called “Transforming India into a Leading Quantum-Powered Economy.” This roadmap explains how India plans to use quantum technology to drive future growth, strengthen national security, and become a global leader in advanced science and innovation.

Quantum technology works very differently from today’s computers and communication systems. It can process information in entirely new ways, allowing scientists to solve problems that are currently too complex or time-consuming. These include discovering new medicines faster, improving climate and weather models, building extremely secure communication networks, developing advanced materials, and enhancing energy systems.

For India, quantum technology is more than just another scientific field. It is seen as a foundation for the next era of development, supporting areas such as artificial intelligence, biotechnology, advanced manufacturing, and digital security. The roadmap highlights that countries investing early in quantum research will shape future global technologies. India wants to be among those leaders rather than catching up later.

The roadmap builds on the National Quantum Mission and carefully reviews India’s current position. It notes that India already has strong scientific talent and engineering expertise, but also identifies areas that need improvement. These include expanding research infrastructure, training a larger skilled workforce, and speeding up the journey from laboratory research to real-world products and services.

A key idea in the roadmap is working together. Success in quantum technology will require cooperation between government agencies, universities, research labs, startups, industries, investors, and state governments. Innovation must move beyond academic research and lead to practical applications that benefit society and the economy.

The roadmap also stresses urgency. Global investment in quantum technology has grown rapidly, and the next few years are considered crucial. Acting quickly will help India avoid dependence on foreign technologies and instead become a trusted supplier of quantum solutions.



### India's Quantum Future: A Simple Roadmap to a Powerful New Technology

Finally, the roadmap presents a global vision. India aims to develop reliable, affordable, and export-ready quantum technologies that can also support other developing countries. By investing in research, talent, and collaboration today, India hopes to build a secure, competitive, and quantum-powered future for everyone.

If implemented effectively, this roadmap could mark a turning point in India’s technological trajectory. By aligning policy, research, and industry, India has the opportunity not only to harness quantum science for national progress, but also to shape a more inclusive and resilient global quantum ecosystem.

#### REFERENCE

NITI Aayog. “NITI Aayog releases a Roadmap on ‘Transforming India into a leading Quantum-Powered Economy’.” Press Information Bureau, Government of India, 04 Dec 2025. [pib.gov.in](http://pib.gov.in)

# INNOVATIONS & PATENTS

Every great invention begins with a bold idea—and a patent to protect it. Innovations drive progress, and patents turn breakthroughs into lasting impact. From lab benches to the marketplace, this is where creativity meets protection.

| By Dr. Avijit Das

## THE THINKING E-RICKSHAW: SOLAR POWER, SMART BRAINS, AND RECYCLED ENERGY

**O**n a bright morning in Lucknow, Asha pulls her e-rickshaw out of the narrow lane. From the top, it doesn't look like an ordinary vehicle: the roof is covered with shining solar panels. But the real magic is hidden inside a tiny "brain" that decides how every watt of energy should be used.

When the sun is strong, the photovoltaic (PV) panels on the roof generate electricity. This power first passes through a boost converter, which acts like a smart valve: it adjusts its duty cycle so the panels always work at their maximum power point, squeezing the most energy out of every ray of sunlight. That energy goes to a common DC bus, shared by the battery and the BLDC motor that drives the wheels.

Here the bidirectional DC-DC converter and the Takagi



Sugeno fuzzy controller come into play. Together, they behave like an intelligent cashier. If the sun is weak and passengers are many, the controller commands the battery to discharge smoothly, avoiding sudden voltage drops and stress. When sunlight is abundant or the rickshaw is waiting at a stand, it orders gentle, efficient charging minimizing overshoot, undershoot, and extending battery life.

As Asha approaches a crowded crossing, she brakes. Instantly, the Voltage Source Inverter stops acting only as a motor driver and starts behaving like a boost converter. The spinning wheels turn the BLDC motor into a generator. Using a special two-boost regenerative method, all three phases of the motor feed energy back into the DC bus. The fuzzy controller adjusts switch timings in milliseconds, matching the motor's back-EMF and rotor speed so that more of that braking energy flows cleanly into the battery instead of disappearing as heat.

By sunset, Asha has carried dozens of passengers using a vehicle that thinks about energy every second harvesting sunlight, recycling motion, and protecting its own battery. That is the true innovation: a solar e-rickshaw whose "intelligent driver system" makes clean transport practical, efficient, and affordable.

If electric rickshaws could intelligently decide—in real time—whether to use solar power, battery power, or regenerated braking energy, what long-term benefit would matter most for society?

- A Passengers would enjoy a quieter ride
- B The vehicle's battery would last longer, reducing waste and replacement costs
- C Drivers would need fewer driving lessons

### INNOVATION

#### Reference:

Singh, M., & Basu, A. (2025). An intelligent driver system for photovoltaic-based e-rickshaws.

**Patent Number:** 202531039580

**Developed by:** National Institute of Technology, Jamshedpur

By Dr. Preeti Sharma

## TINY PARTICLES, BIG PROTECTION: NANO-PARAPHEROMONES AGAINST MELON FLY

**F**armers growing cucurbits like bitter gourd, cucumber, pumpkin, and melon know one enemy too well: the melon fruit fly. This small insect can destroy up to 80% of a crop, leaving farmers helpless and forcing many to spray pesticides again and again. But pesticides bring their own problems: resistance, chemical residues, and harm to the environment. Scientists wanted a safer, smarter way to fight the melon fly. They focused on something nature already uses: parapheromones chemicals that attract only the male fruit flies. One parapheromone, 4-(p-acetoxyphenyl)-2-butanone, is very powerful. But it



evaporates too fast, breaks down in sunlight, and stops working after a short time. Farmers need to replace it often, making it expensive and less effective.

This challenge inspired the invention of a nano parapheromone formulation, a technology that combines nanoscience with natural plant extracts.

The story begins with the *Moringa oleifera* tree, known for its nutritious leaves. When the leaves are boiled, they release natural compounds that can help create nanoparticles. Scientists used moringa leaf extract to biosynthesize titanium dioxide nanoparticles tiny, oval-shaped particles only 50–60 nanometers wide.

These nanoparticles act like tiny storage rooms with many pores. When mixed with the parapheromone, something exciting happens: the parapheromone molecules get trapped inside these pores through gentle electrostatic attraction. This creates a slow-release nanofomulation. Instead of evaporating quickly, the parapheromone now escapes slowly and steadily protected from sunlight, heat, and oxygen. This means longer shelf life, longer field activity, and more male flies attracted for many weeks.

Field trials across Tamil Nadu showed stunning results. Nano-parapheromone traps caught far more fruit flies sometimes three times more than commercial traps. Even better, they lasted 14 weeks, while normal traps stopped working after 7 weeks. Crop damage fell, yields increased, and farmers earned more profit with a high cost-benefit ratio (1:412).

This innovation is simple, natural, cost-effective, and farmer-friendly. By blending plant extracts, nanotechnology, and insect behavior, it gives agriculture a cleaner, smarter weapon against the melon fly helping farmers grow safer, healthier cucurbit crops.

### INNOVATION

#### Reference:

Kannan, M. (2025), Nano parapheromone formulation for control of melon fly and preparation method thereof.

Patent Number: 202541010177

Developed by: Department of Agricultural Entomology, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore.

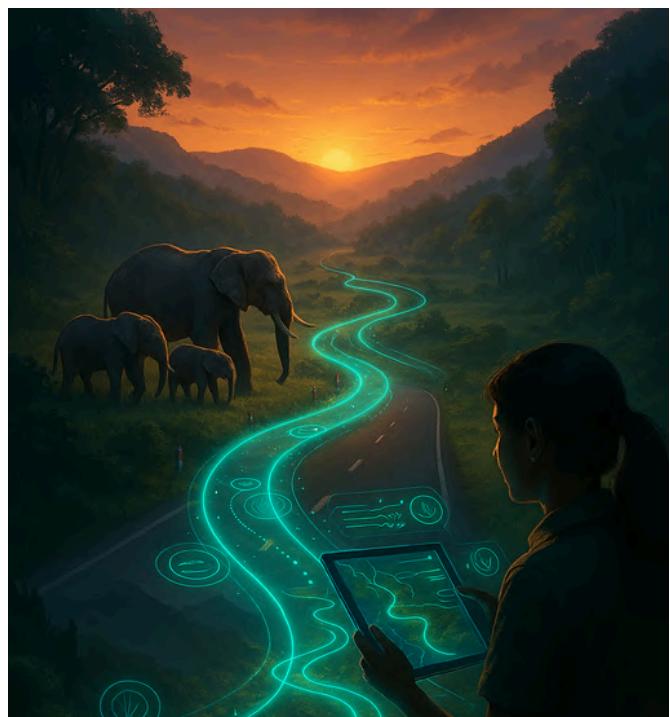
By Dr. Sudha Shankar

## THE CORRIDOR THE FOREST COULD FINALLY SEE

**A**t dawn in a forested valley, Priya, a young wildlife officer, watched a herd of elephants hesitate at the edge of a busy highway. One side held their feeding grounds; the other, a shrinking patch of forest. For years, animals had tried to cross here and been blocked by roads, farms, and villages. Priya knew they needed a safe corridor but where should it be?

Her team used maps, GPS collars, and satellite images, but each told only part of the story. Some maps showed forests but ignored cliffs. Camera traps caught tigers and deer, but only in scattered spots. Scientists, forest guards, and local people all argued for different “best routes,” and no one trusted the old models that drew lines on maps without explaining why.

That year, Priya’s department deployed a new system based on explainable artificial intelligence, or XAI. Across the landscape they installed smart sensors devices measuring slope, soil moisture, vegetation, river levels, temperature, and motion-activated cameras capturing animals day and night. Each sensor sent data to a field control unit, which uploaded everything to a secure cloud server.



There, AI models learned from the massive stream of information: where animals moved, which ridges they avoided, how close they stayed to rivers, and where human activity formed invisible barriers. Unlike a “black box,” this AI explained itself. On Priya’s dashboard, corridor suggestions appeared as glowing paths with reasons like: “Gentle slopes preferred,” “High vegetation cover,” “Low human disturbance,” “Water proximity critical.”

When Priya proposed a new underpass and protected corridor, she could show communities and engineers exactly why the route mattered. People questioned the model, adjusted settings, and immediately saw updated results.

In the end, the elephants gained a safe passage and Priya gained something just as valuable: a transparent, trustworthy partner that turned scattered data into clear, shared decisions for conservation.

**When Priya used the new explainable AI system, what was the biggest advantage it gave her compared to old wildlife corridor models?**

- A) It created prettier maps for presentations
- B) It showed why certain paths were safer, not just where they were
- C) It worked only when elephants were nearby

### INNOVATION

#### Reference:

Paranjape, V., Sharma, S., Dwivedi, M., Vishwakarma, Z., Choubey, J., Pateriya, N., & Gupta, Y. (2025). System for wildlife corridor monitoring and mapping using explainable artificial intelligence (XAI) for biodiversity conservation.

 **Patent Number:** 202421042504

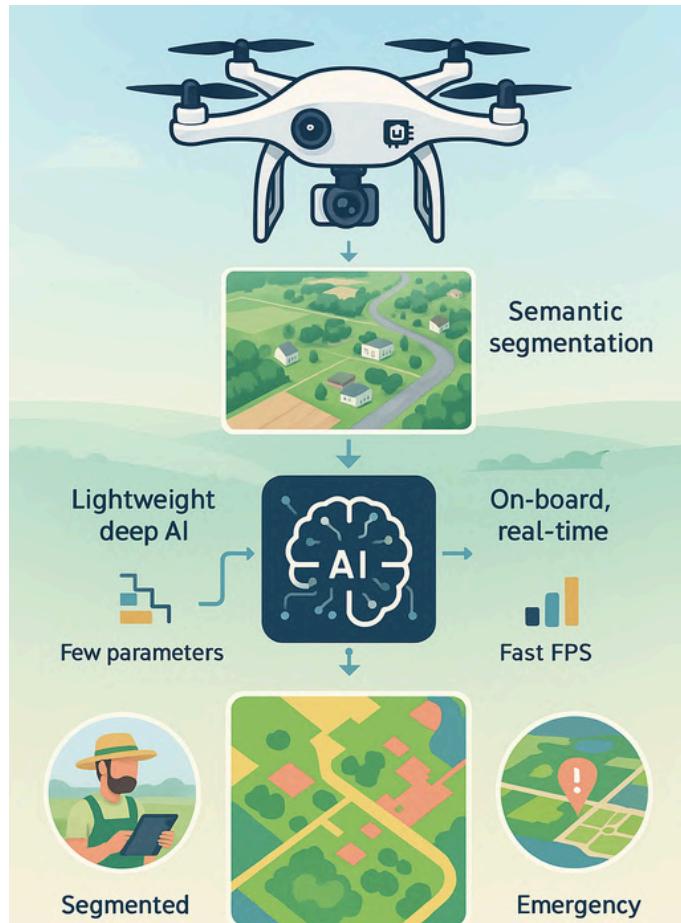
 **Developed by:** Baderia Global Institute of Engineering and Management - 482002

| By Dr. Poulami Chakraborty

## THE DRONE THAT COULD THINK IN THE SKY

**E**very morning, Riya launched a small quadcopter from the edge of a farming village. At first glance, her drone looked ordinary: a camera, a GPS, and the usual flight controller. But inside, it carried something new: a tiny “brain” made of two computers working together.

The first computer handled normal flying jobs: keeping the drone stable, following waypoints, talking to the ground station. The second was more special. It had a small GPU, just like a mini version of the graphics cards used in big AI servers. Its job was to look at each video frame in real time and decide, pixel by pixel, what the ground below was made of: road, crop, tree, building, water, or background.



Before flights, a powerful computer at the base station trained a lightweight deep-learning model using many aerial images and their correct “colour-coded” masks. This model learned to recognise patterns with far fewer parameters than big, heavy networks like U-Net or

DeepLab. Once training and testing were done, the compact model was sent back to the drone and stored on its onboard chip. Now, when Riya’s drone flew, images went from the camera through a simple pre-processing step and then straight to the GPU module. Within a fraction of a second, the drone produced a land map where every pixel was classified. No more waiting to upload gigabytes of data to a distant server. The results could be streamed instantly to phones and laptops on the ground.

During floods, the system highlighted damaged roads and submerged fields. In normal times, it helped farmers see crop health patterns and local officials measure encroachment or plan new roads. Because the model was efficient, it avoided overfitting, ran at 9–12 frames per second, and could even detect small objects like vehicles. Riya liked to say her drone didn’t just see the land anymore; it actually understood it while it was still in the air.

### Why is it important for the drone to process aerial images onboard instead of sending them to a distant server for analysis?

- A** It makes the drone look more modern
- B** It reduces delay, allowing the drone to generate land maps instantly during flight
- C** It increases the drone’s battery consumption
- D** It allows the drone to store more photos for social media

### INNOVATION

#### Reference:

Sindhwan, J. N., & Arora, S. (2023). *A method to enhance the efficiency of electricity generation by minimizing magnetic drag using a specific coil and magnet arrangement.*

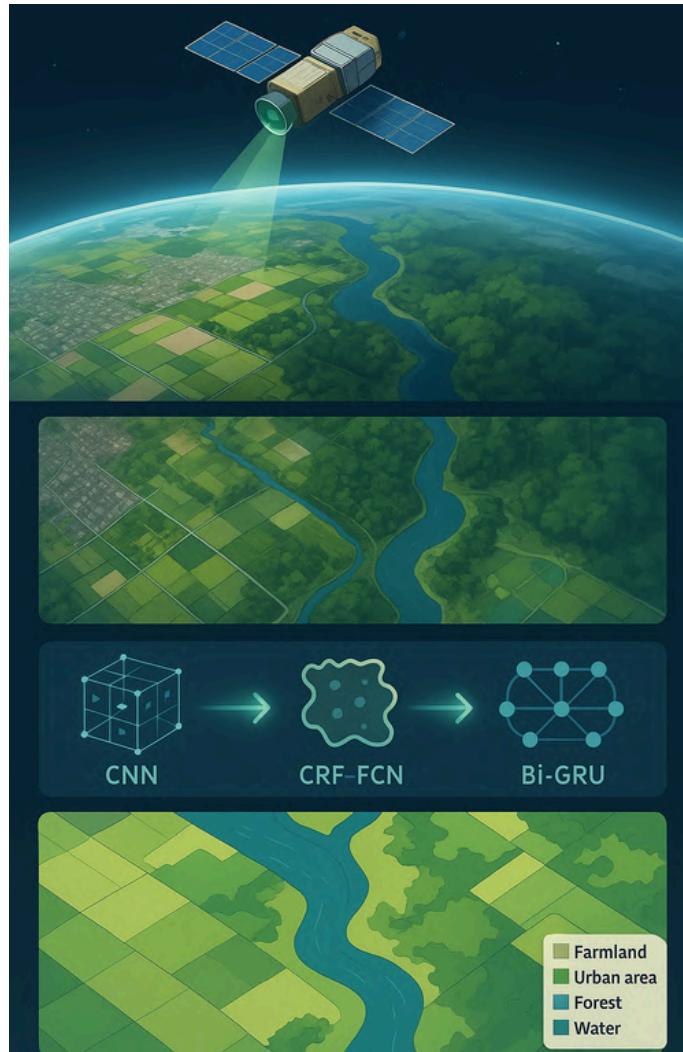
**Patent Number:** 571519

**Developed by:** -A to Z Services Pvt Ltd C, Mumbai, India.

## THE MACHINE THAT COULD READ THE EARTH

Every morning at the Earth Observation Centre, a young researcher named Riya opened her laptop to check the latest satellite images from the Sentinel-2 satellite. These pictures were beautiful patches of green forests, blue lakes, glowing cities, and farmland divided like a giant puzzle. But Riya had a problem: she needed to label every part of these images correctly forest, water, buildings, roads, crops. Doing this manually would take months and often led to errors.

Old systems tried to help by using simple neural networks, but they failed in difficult situations. Some models worked only with aerial photos, not with multi-spectral satellite images. Others labelled images column by column or depended heavily on camera depth. None could handle the



huge amount of information coming from modern satellites or adapt to seasonal changes. One evening, Riya and her team built something new a system that combined three powerful deep-learning tools: a Convolutional Neural Network (CNN) to extract spatial, spectral, and object-level details; a CRF-FCN model to check the relationships between pixels and refine the labels; and a Bi-Directional GRU that learned how spectral values changed over time and how they related to each other. They fed the system multi-spectral images from Sentinel-2. The CNN studied patterns like colour, texture, and shapes. The CRF-FCN compared these patterns with ground truth labels, reducing noise and mistakes. The Bi-GRU looked both forward and backward in the data sequence to understand complex temporal patterns more deeply.

One morning, Riya pressed a button and the screen lit up with perfectly annotated land maps. The system could finally “read” Earth on its own.

With this invention, researchers could train deep-learning models on huge datasets, improve accuracy through real labels, and predict land-use changes far more easily.

Riya smiled. Her machine didn’t just label images.

It helped humans understand the planet better each day.

### Why is the Bi-Directional GRU (Bi-GRU) used in this annotation system?

- A To make satellite images look sharper
- B To learn pixel-based patterns using both past and future spectral information
- C To replace the CNN entirely
- D To download images faster from the satellite

### INNOVATION

#### Reference:

Afaq, Y., Manocha, A., Singh, R., Gehlot, A., Rathour, N., Thakur, A., & Mani, S. (2025). System of automatic annotation of multi-spectral high-resolution satellite images using deep learning approach.

**Patent Number:** 202111056871

**Developed by:** LOVELY PROFESSIONAL UNIVERSITY, PUNJAB.

## Prof. Vaidyeswaran Rajaraman

India lost one of its quiet giants on 8 November 2025, when Prof. Vaidyeswaran Rajaraman, the pioneer who built the foundations of computer science education in the country, passed away in Bengaluru at the age of 92. To generations of students, teachers, and researchers, he was the voice that shaped how India understood computing long before the digital revolution began.

Born on 8 September 1933 in Erode in the Madras Presidency, Rajaraman's early education began in a Tamil-medium school, a fact he later credited for giving him both clarity of thought and a deep love for self-learning. After graduating from MIT (Massachusetts Institute of Technology) and completing his PhD at the University of Wisconsin, he returned to India at a time when computers were rare, expensive, and poorly understood. That decision alone changed the course of Indian science.

In 1965, Rajaraman helped establish the first academic programme in computer science at IIT Kanpur, a landmark that marked the birth of formal computing education in India. He played a central role in developing the curriculum, setting up early computer laboratories, and introducing students to programming and systems thinking at a time when India had neither hardware nor institutional support. When the country's first IBM 1620 computer reached IIT Kanpur by bullock cart, it was Rajaraman who transformed that symbol of scarcity into a world-class learning opportunity.

As a teacher, Rajaraman was unmatched. His textbooks particularly "Fundamentals of Computers," "Programming in FORTRAN," and the later editions in the TMH computer science series became the gateway through which millions of Indian students entered the world of computing. Across engineering colleges, universities, and training institutes, his books shaped computer literacy for decades. Even today, many senior faculty in India describe Rajaraman not just as an author, but as their first teacher in computer science.

Prof. Rajaraman's research contributions spanned computer architecture, parallel processing, programming languages, and scientific computing. He was a Fellow of all the major Indian science academies and the recipient of the Shanti Swarup Bhatnagar Prize (1976) and the Padma Bhushan (1998). His visionary leadership also supported

**THE ARCHITECT OF  
INDIAN COMPUTER  
SCIENCE EDUCATION**  
**(1933–2025)**



the creation of computational tools in the early days of ISRO, TIFR, and national laboratories, laying the foundation for India's later digital expansion.

What made him extraordinary was his lifelong belief that computing should be "simple, accessible, and empowering." Long before the era of Python, cloud computing, and AI, he emphasized conceptual clarity over jargon, fundamentals over fashion, and teaching over prestige. He mentored hundreds of students who went on to build India's software, education, and research ecosystems.

Even in his later years, Rajaraman continued writing, revising textbooks, and advising students. His curiosity never faded; he often remarked that "computing is not about machines it is about thinking."

With his passing, India bids farewell to a visionary who gave the country not just knowledge, but confidence that Indian students could master, create, and lead in the digital world. His legacy lives on in classrooms, laboratories, and the minds of millions who learned their very first lines of code through his words.

As India moves deeper into the age of artificial intelligence and digital transformation, Prof. Rajaraman's legacy serves as a compass. His insistence on strong foundations, clarity of thought, and inclusive education reminds us that technology advances fastest when learning remains human-centred and accessible to all.

Future generations will continue to build upon the foundations he laid, guided by his belief that true progress in computing begins with disciplined thinking, curiosity, and a commitment to education.

# SCIENCE NEWS & OPPORTUNITIES

By  
Rosalind Franklin  
Council of Scientific Research  
(**RFCR**)

"Science News & Opportunities" keeps you updated with the latest scientific breakthroughs and opens doors to exciting careers, scholarships, and research programs.



## K. S. Krishnan: Architect of Crystal Magnetism

01

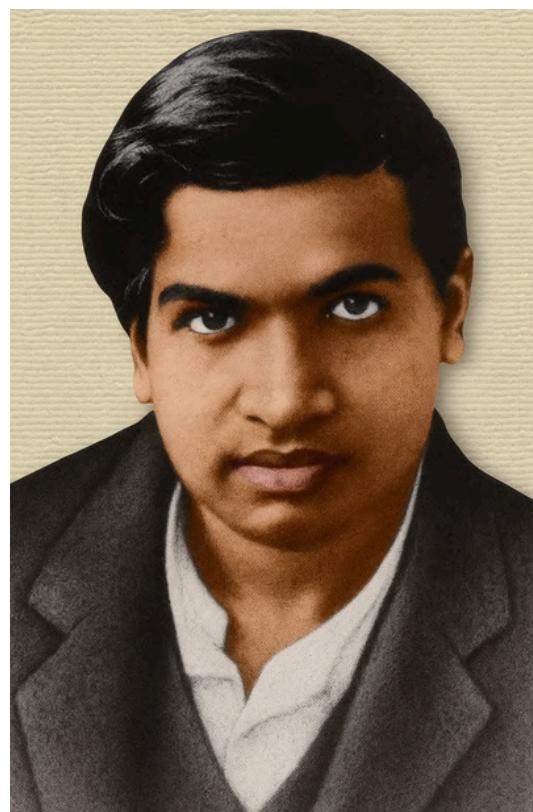
Dr. K. S. Krishnan (1898–1961), born in Watrap, Tamil Nadu, was a pioneering Indian physicist who helped lay the foundations of condensed matter physics in India. A brilliant experimentalist, he worked closely with Sir C. V. Raman and played a key role in the discovery of the Raman Effect in 1928. Krishnan later established his own scientific identity through groundbreaking research on crystallography and magnetism. He systematically studied magnetic susceptibility and revealed how magnetic properties depend on crystal structure and direction. His elegant methods for measuring magnetic anisotropy became influential tools in materials research. Beyond his scientific achievements, Krishnan was a dedicated mentor and institution builder who strengthened India's research culture. Quiet, rigorous, and deeply principled, his legacy continues to shape modern solid-state physics.



## The Eternal Genius: Srinivasa Ramanujan's Journey Through Numbers

02

Born on December 22, 1887, in Erode, Tamil Nadu, Srinivasa Ramanujan was a mathematical prodigy whose intuition reshaped modern mathematics. With little formal training, he mastered advanced trigonometry as a teenager and began creating original theorems, guided by an innate sense of numerical truth. Though he struggled in other subjects, his notebooks overflowed with elegant identities and infinite series. His work reached British mathematician G. H. Hardy, who invited him to Cambridge in 1914. There, Ramanujan produced groundbreaking contributions to number theory, partitions, and modular forms. Elected a Fellow of the Royal Society in 1918, his life ended tragically at 32. Yet his ideas continue to inspire mathematics, physics, and cryptography worldwide.



# Things YET TO BE DISCOVERED

From the dark depths of our oceans to the farthest reaches of the cosmos, countless mysteries remain unsolved. Science continues to push the boundaries of the known, revealing just how much is still left to uncover. What lies beyond our current understanding may reshape the future of humanity.

| By Dr. Avijit Das

# Whispers From 12 Billion Years Ago: The Enigma of Galaxy Alaknanda

Indian astronomers have helped make an extraordinary discovery: a distant galaxy named Alaknanda, located almost 12 billion light-years away. Because its light has travelled for so long to reach us, we are seeing this galaxy as it looked when the universe was still very young only about a billion years after the Big Bang. What has amazed scientists around the world is that Alaknanda looks strikingly similar to the Milky Way, even though galaxies from that time period were expected to be messy, irregular, and full of violent activity.

In the early universe, young galaxies were usually clumpy collections of gas and stars, constantly crashing into each other and growing through frequent mergers. They were not calm or well-structured. Spiral galaxies like the Milky Way with its graceful, organized arms were believed to form much later, after billions of years of settling and rotation. This is why Alaknanda is such a surprising find. Despite belonging to a chaotic era, it already has clear spiral arms, a stable disk, and a shape that suggests it had matured far earlier than expected.

This discovery has opened up many scientific questions. One major puzzle is: How did such a perfectly shaped spiral galaxy form so quickly? Scientists think that Alaknanda may have experienced a very peaceful life compared to other galaxies at that time.

It might not have collided with its neighbours as often, allowing gas and dust to slowly settle into a neat spiral pattern. Another idea is that its dark matter halo, the invisible structure that provides a galaxy's gravitational support, formed rapidly and gave the galaxy the stability it needed at an early age.

But there is still much we do not know. Is Alaknanda a rare case of early galaxy formation, or have astronomers simply not been able to detect many others like it yet? Does its existence mean that the early universe had special conditions that helped spiral galaxies form faster? Or could it mean that our current theories about galaxy formation are missing an important piece of the puzzle? These mysteries make Alaknanda an exciting subject for future research.

Astronomers used a combination of advanced ultraviolet and infrared telescopes both Indian and international to observe the faint light coming from Alaknanda. Because the universe has been expanding for billions of years, the light from distant galaxies stretches into longer wavelengths. This is why infrared observations are especially important: they allow astronomers to see what ordinary telescopes cannot detect. The fact that this fragile signal travelled for 12 billion years through empty space past stars, nebulae, and galactic dust before reaching our detectors makes the discovery even more incredible.

The galaxy's name, Alaknanda, comes from one of India's sacred Himalayan rivers. The name adds a poetic touch to the discovery. Just as the river carries stories of mountains, valleys, and ancient traditions, the galaxy Alaknanda carries the story of the early



universe memories from a time when the cosmos itself was young and still learning how to build order out of chaos.

Researchers now want to learn much more about this galaxy. They hope to study how fast it rotates, which will tell them about the spread of dark matter inside it. They also want to examine the chemical makeup of its stars to understand how quickly heavier elements formed after the Big Bang. If scientists can find more galaxies like Alaknanda, they might be able to determine whether the early universe was far more organized than previously believed.

In many ways, Galaxy Alaknanda is a cosmic reminder that the universe is full of surprises. It shows that even in the most ancient chapters of cosmic history, order and beauty could emerge much earlier than anyone expected. And it reminds us that across 12 billion light-years, across unimaginable distances and time, something familiar can still shine through a spiral of stars quietly turning in the darkness, telling a story we are only just beginning to understand.

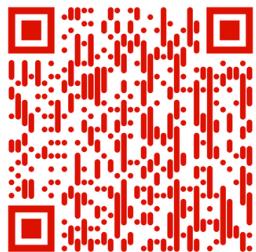
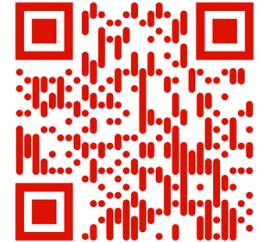
Future generations will continue to build upon the foundations he laid, guided by his belief that true progress in computing begins with disciplined thinking, curiosity, and a commitment to education.

## REFERENCE

Jain, R., & Wadadekar, Y. (2025). A grand-design spiral galaxy 1.5 billion years after the Big Bang with JWST.

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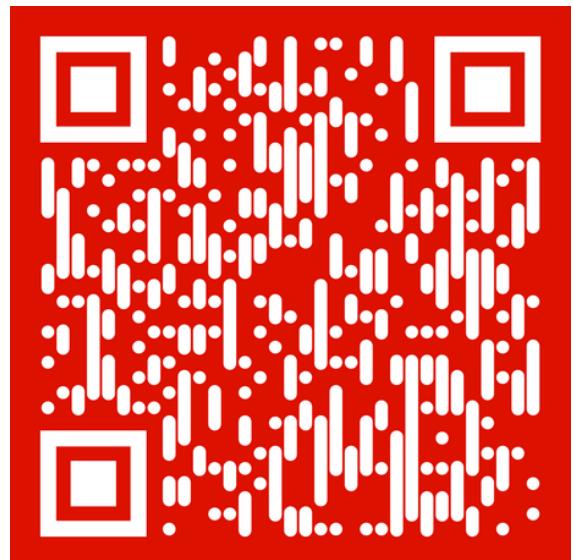


## SHOWCASE: SCIENTIFIC RESEARCH

A Researcher Showcase is a platform designed to highlight the innovative work and contributions of researchers across various fields. It provides an opportunity for scholars to present their findings, exchange ideas, and foster collaborations. RFCSR's showcases helps researchers with networking opportunities to celebrate and support academic and scientific progress.

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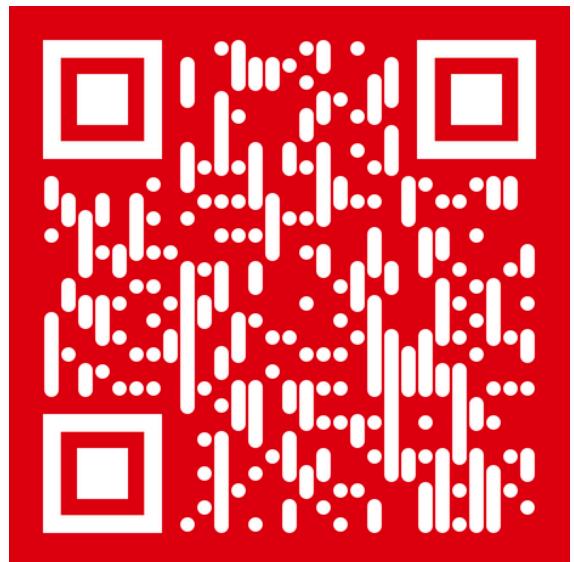
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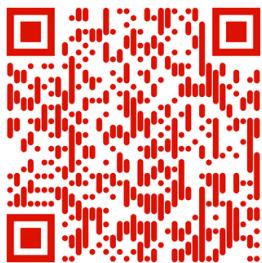
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At Rosalind Franklin Council of Scientific Research (RFCR), we recognize that the pursuit of science is both inspiring and demanding. Alongside the excitement of discovery, researchers often face unique challenges—intense workloads, high expectations, uncertainty about the future, and at times the discouraging experience of non-cooperation within their professional field or the feeling of being stuck in their career path. Such moments can leave even the most dedicated scientists questioning their way forward.



RESEARCHERS LIFELINE RESEARCH HEALTH



# back to school



CURIOS KID'S

NAME: Riddhiman Singh

Age: 4 Years

SCHOOL: Junior Delhi Public School

FOCUS:

## My Feelings, My Colors!

This is a chameleon. It can change its color, not like paint, but to show its feelings.

When it is calm, it stays green.

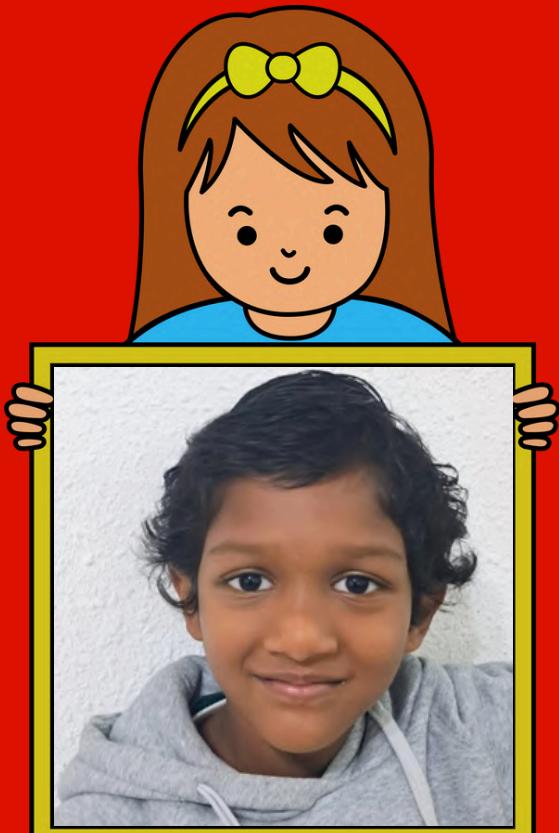
When it feels angry or scared, it turns dark.

When it is excited or hot, it becomes bright.

Its colors show how it feels inside



# back to school



CURIOS KID'S

NAME: Shai Sri Rakshan

Age: 6 Years

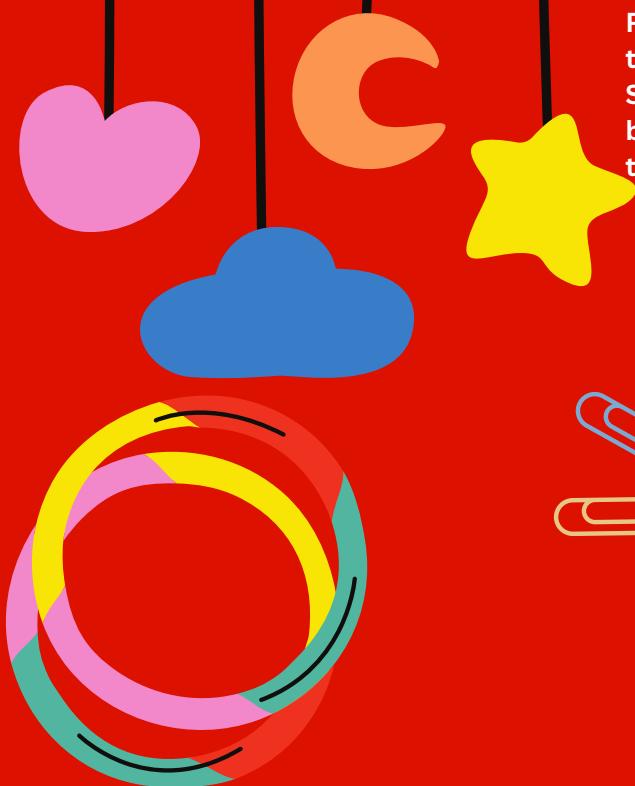


SCHOOL: Moshe Smilansky School Rehovot, Israel

FOCUS:

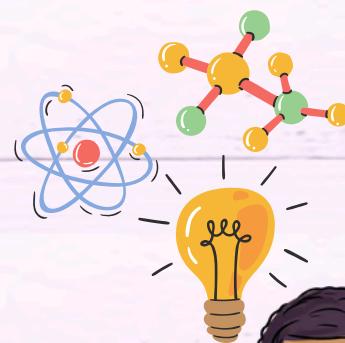
## Look but Don't Touch!

These frogs are very bright and colorful. Their colors work like a warning sign. They are saying, "Do not touch me!" Poison dart frogs have poison in their skin. If another animal touches or bites them, it can feel pain and become very sick. So predators learn to stay away. Long ago, people used a little bit of this frog's poison on arrows for hunting. That is why they are called poison dart frogs.



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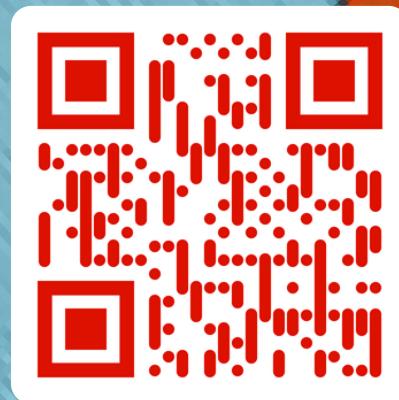
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