SCIENCE FACTORS.

INSIGHT, DISCOVERY, LEARNING, INNOVATION, AND IMPACT

By
Rosalind Franklin
Council of Scientific Research (RFCSR)
April 25, 2026

THE NEXT PANDEMIC IS BEING BUILT— SILENTLY

How hidden biological systems are shaping global health risks.

SPILLOVER !

HIDDEN NETWORKS, GLOBAL OUTBREAKS

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Scientific Research Empowers Social Progress !

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"In a world flooded with information, *Science Factors* stands out for its clarity, creativity, and commitment to truth. It brings the latest discoveries from top global journals into classrooms, cafés, and conversations—without losing the wonder that makes science so human. I believe this magazine will inspire not just students, but scientists too, to see their work through fresh, curious eyes."

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LETTER *from the* EDITOR

Dr. Animesha Rath
The Editor-in-Chief

Dear Readers,

In this issue of Science Factors, we bring into focus a reality that is quietly unfolding around us one that demands both scientific understanding and collective awareness. Our cover theme, "The Next Pandemic Is Being Built—Silently," reflects a deeper truth: global crises do not begin with headlines; they begin with subtle, interconnected changes that often go unnoticed.

As explored in this issue, the emergence of disease is not an isolated event but a process shaped by human behavior, environmental shifts, and biological evolution. From the hidden dynamics of wildlife trade to the microscopic battles between pathogens and hosts, science reveals that the foundations of future pandemics are already being laid gradually, silently, and systematically.

Yet, this issue is not only about risks it is equally about the power of science to understand, adapt, and respond.

Our featured stories take you across scales of discovery. From uncovering how cholera evolves and spreads through complex ecological and human networks, to exploring how brain structure shapes learning in even the smallest organisms like bees, we see a common theme emerge: systems whether biological, environmental, or societal are deeply interconnected.

In our expert perspectives, we move further into the unseen. The human gut microbiome, for instance, reminds us that health is not defined by a single factor, but by entire ecosystems living within us. Similarly, research into the circadian clock reveals how even the rhythm of life itself is governed by delicate molecular interactions. These insights reinforce a powerful idea: small changes at the microscopic level can have profound impacts on life at the macroscopic scale.

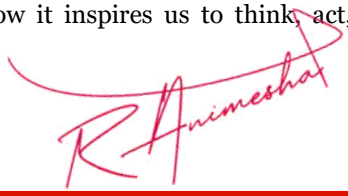
At the same time, innovation continues to push boundaries. Advances such as 3D bioprinting and bioengineered systems demonstrate how science is not only uncovering problems but actively building solutions for the future of medicine and human health.

Across all these stories, one message becomes clear:
Science is most powerful when it connects knowledge to impact.

At *Science Factors*, our vision of Science for Society remains at the core of everything we do to transform discovery into understanding, and understanding into meaningful action.

As you turn these pages, we invite you not only to explore science, but to reflect on its role in shaping the world around us. Because the true strength of science lies not just in what it reveals, but in how it inspires us to think, act, and build a better future.

Happy reading.



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SCIENTIFIC RESEARCH EMPOWERS SOCIAL PROGRESS !

The CONTRIBUTORS

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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

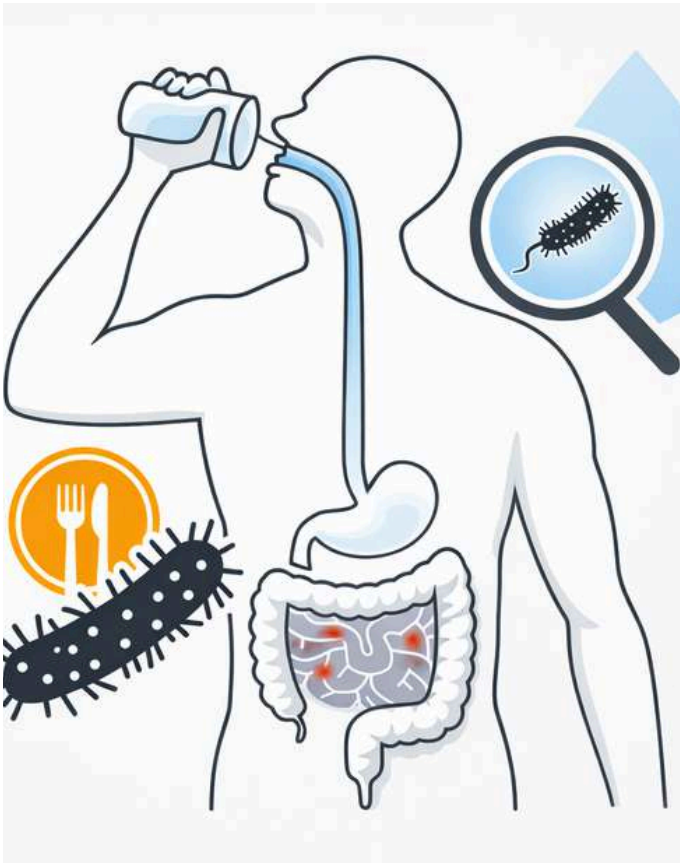
THE HIDDEN JOURNEY OF CHOLERA

FEATURED

In a quiet laboratory in the UK, Dr. Eleanor Hayes stared at a glowing screen filled with genetic data. Each line represented a tiny bacterium, Vibrio cholerae, the cause of cholera a disease that has troubled humanity for centuries. “We know cholera spreads,” she said softly to her team, “but do we really understand how and from where?”

Her colleagues, including Dr. Rafiq Hasan in Bangladesh and Dr. Meera Kapoor in India, had spent years collecting samples from patients. Together, they had built one of the largest datasets ever, with thousands of bacterial samples collected over more than 20 years. Their mission was simple but challenging: to uncover how cholera evolves and spreads across the world.

In Dhaka, Bangladesh, Dr. Hasan walked through a busy



hospital ward where cholera patients were being treated. The disease was common here, especially during outbreaks. Every sample collected from patients carried a hidden story inside its DNA. Meanwhile, in Chandigarh, India, Dr. Kapoor and her team were collecting similar samples, carefully storing them for genetic analysis. Though the two regions were geographically close, the scientists wondered if the bacteria behaved the same way in both places.

Back in the lab, Eleanor and her team began comparing the DNA sequences. Soon, a pattern started to emerge. “Look at this,” said one researcher. “The bacteria in Bangladesh and India are similar, but they are not mixing as much as we expected.” It was surprising. Scientists had long believed that cholera spread mainly through rivers like the Ganges, connecting the two countries. But the data suggested something different. National borders seemed to limit the spread more than water systems.

As they dug deeper, the team discovered two main groups of cholera bacteria, called BD1 and BD2. These groups were like two competing families. In Bangladesh, BD2 dominated for several years, but suddenly, in 2018, BD1 replaced it completely. “It’s like one team took over the

| By Dr. Sivan Friedman

entire field overnight," Eleanor explained. This rapid change showed how quickly bacteria can evolve and adapt.

But what caused one group to replace another? The answer lay in tiny genetic changes. The bacteria were constantly gaining and losing genes some helping them survive, others affecting how dangerous they were. In Bangladesh, many bacteria lost genes that protect them from viruses called bacteriophages. At first, this seemed risky, but it had an unexpected effect. Without these protective genes, the bacteria could grow faster inside the human body, making the disease more severe.

Meanwhile, something equally fascinating was happening with the viruses themselves. A virus called ICP1 was changing alongside the bacteria. When BD1 replaced BD2 in 2018, the virus also changed its form. "It's like an arms race," said Eleanor. "The bacteria evolve to escape the virus, and the virus evolves to catch them again."

The team also studied how cholera spreads within Bangladesh. They found that once a new bacterial type appears, it spreads quickly across the country, often within a year. Cities like Dhaka act as central hubs, sending the infection to other regions. Human movement, not just water, plays a key role in spreading the disease.

But the biggest surprise came when they looked at global outbreaks. Even though Bangladesh has many cholera cases, most international outbreaks seem to start from India. Strains from India were linked to outbreaks in Africa, Europe, and even the massive Haiti outbreak in 2010. "This changes everything," Eleanor said. "The Ganges Basin is not just a source, it's a launch pad for global spread."

The team also noticed that some bacteria carried special genetic elements that protected them from viruses. However, these same bacteria were less likely to spread to other countries. It was as if these protective features helped them survive locally but made them less successful globally.

After years of work, the scientists stepped back and looked at the bigger picture. Cholera was not just a disease moving through water; it was a constantly evolving system shaped by bacteria, viruses, and human behavior. Borders, cities, and movement patterns all played a role.

Standing by the window, watching the world outside, Eleanor reflected on their discovery. "Cholera doesn't just just appear suddenly," she said. "It evolves, adapts, and spreads quietly over time. If we want to stop it, we must understand its journey."

She paused, then added, "This knowledge gives us power not just to react, but to predict." By tracking genetic changes in real time, scientists may one day forecast outbreaks before they begin. Such insights could guide vaccines, improve surveillance, and save lives. The story of cholera, once hidden in microscopic code, is now becoming a map for global health preparedness.

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By Dr. Preeti Sharma

DOES A BIGGER BRAIN MAKE A BEE SMARTER?

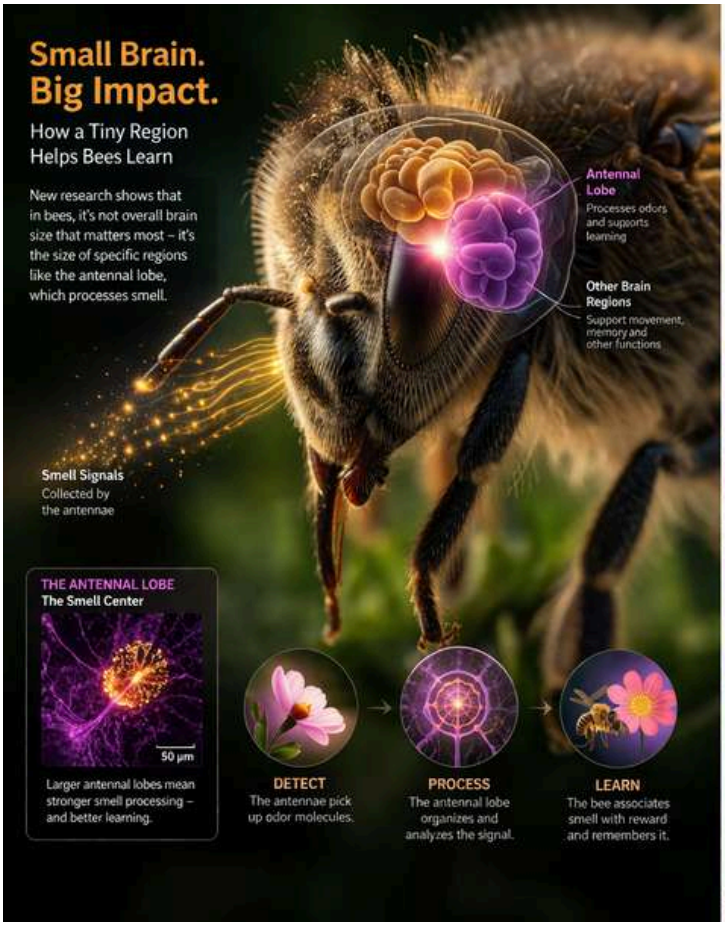
FEATURED

In a quiet research lab in France, Dr. Elina Martin watched a tiny honey bee carefully moving inside a small experimental setup. To most people, bees looked simple, but to her, they were full of mysteries. “Do bigger brains really make animals smarter?” she asked her team. It was a question scientists had been debating for many years. Alongside her colleagues Dr. Matteo Lemaire and Dr. Clara Bernard she decided to explore this question using bees, creatures known for their surprising learning abilities despite their tiny brains.

The team began by studying thousands of bees, both honey bees and bumblebees. At first, they focused on something simple- head size. Surprisingly, even within the same species, bees showed clear differences. Some had slightly larger heads, while others were smaller. “If the head is bigger, the brain inside is likely bigger too,” Matteo explained. But size alone did not mean anything unless it affected behavior. So, the team designed experiments to test how well these bees could learn. They used smell-based learning tasks, where bees were trained to associate a specific odor with a sweet sugar reward. Over time, the bees learned to recognize the smell and respond quickly, even before receiving the reward.

As the experiments continued, a clear pattern appeared. Bees with larger heads were learning faster and making fewer mistakes. They were better at remembering smells and could even handle more difficult tasks, such as distinguishing between similar odors or changing what they had learned earlier. Clara looked at the data and smiled. “This is not random,” she said. “There is something important happening here.” The team realized that bigger brains might indeed help bees learn better but they needed to understand why.

To find the answer, Elina used advanced imaging techniques to look inside the bee brain. The images revealed something fascinating. While larger bees had bigger brains overall, one part stood out the antennal lobe.



By Dr. Preeti Sharma

This region is responsible for processing smells. Bees with larger antennal lobes performed much better in learning tasks. “It’s like they have a stronger signal system,” Elina explained. “They can process smells more clearly, which helps them learn faster.” This showed that it was not just brain size, but the size of specific brain regions that mattered most.

However, the story did not end there. The team wanted to test if bigger brains also improved other types of learning, like recognizing colors. They ran new experiments where bees had to learn visual patterns instead of smells. To their surprise, the results were different. Larger bees did not perform better in these visual tasks. “So, bigger brains don’t make bees better at everything,” Matteo said. “It depends on the type of learning.” This discovery helped them understand that brain size is not a simple measure of intelligence. Instead, specific brain regions are linked to specific skills.

The team also studied bumblebees and found a similar pattern. Larger bumblebees, with bigger heads and brains, were also better at smell-based learning. This confirmed that the relationship between brain size and learning was not limited to just one species. But another important question remained do bees become smarter because they learn more, or are they born with these differences? After careful analysis, the team concluded that bees with larger brain structures already have better learning abilities. These differences likely develop early in life and may be influenced by nutrition or environmental conditions.

As the sun set outside the lab, Elina reflected on their findings. “Nature is more complex than we think,” she said softly. “It’s not just about having a bigger brain it’s about how that brain is built.” The team realized that in social insects like bees, having individuals with different abilities might actually benefit the whole colony. Some bees may be better learners and help find food quickly, while others perform different roles. But they also understood a warning: environmental stress could reduce brain size and harm learning, affecting the entire colony’s survival.

In the end, their research revealed a simple but powerful idea. A bigger brain can help but only when it improves the right function. And in the tiny world of bees, even the smallest differences can make a big impact.

These findings fit with what scientists know about brains and behavior. Intelligence is not just about having a bigger brain, but about how well certain parts of the brain are developed and used. In bees, areas like the antennal lobes and mushroom bodies help with smelling, learning, and memory.

These brain parts can grow differently depending on factors like food, environment, and colony conditions. Even small differences in brain structure can lead to clear changes in behavior. This shows that being specialized for certain tasks is more important than just having a larger brain.

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| By Dr. Ipsita Mohanty

THE MARKET THAT SPOKE IN SILENCE

FEATURED

In the quiet city of Fribourg, Julien Moreau spent most of his days studying patterns others could not see. As a researcher interested in how diseases move between animals and humans, he often felt the real story was hidden beneath what people notice. One morning, he gathered his team Claire Morel, Adrian Keller, and Elise Dubois and posed a simple question: “What if diseases don’t just appear suddenly, but build slowly over time through our interactions with animals?” The team realized they needed to examine something common yet rarely questioned the global wildlife trade, a complex system linking ecosystems, economies, and human behaviour across continents.

Over the next few weeks, the team analyzed a dataset covering more than forty years. They studied thousands of mammal species, comparing those involved in wildlife trade with those living freely. As Adrian processed the data, a striking pattern emerged. Animals in trade were far more likely to carry diseases that could infect humans. Nearly half of the traded species shared at least one pathogen with humans, while only a small fraction of non-traded species showed similar connections. This difference was too large to ignore. It clearly suggested that wildlife trade plays a major role in disease transmission.

Looking closer, the team found that these pathogens included viruses, bacteria, and parasites, many of which are capable of adapting to new hosts. Some even showed signs of rapid evolution when species were repeatedly brought into contact. This indicated that wildlife trade does not just spread diseases, it can also accelerate their evolution by creating new opportunities for pathogens to adapt and diversify.

As they discussed the results, Claire pointed out that the trade process itself explains this pattern. Animals are captured, transported over long distances, stored in crowded conditions, and sold in markets where humans handle them frequently. At each step, species that would never interact come into close contact. Julien added that these repeated interactions create opportunities for pathogens to jump to humans, a process scientists call spillover. The team realized the risk is not just about the animals, but about how humans bring species together in unnatural ways, often without understanding the biological consequences.

What worried them most was how the risk changes over time. Adrian discovered that the longer a species remains

| By Dr. Ipsita Mohanty

part of the wildlife trade, the more pathogens it shares with humans. On average, every ten years of involvement adds one more pathogen that can infect people. This meant the danger is not fixed, it grows steadily. Elise reflected that it is like building an invisible connection between species, becoming stronger with repeated contact. Over time, these connections can form hidden transmission pathways that make future outbreaks more likely.

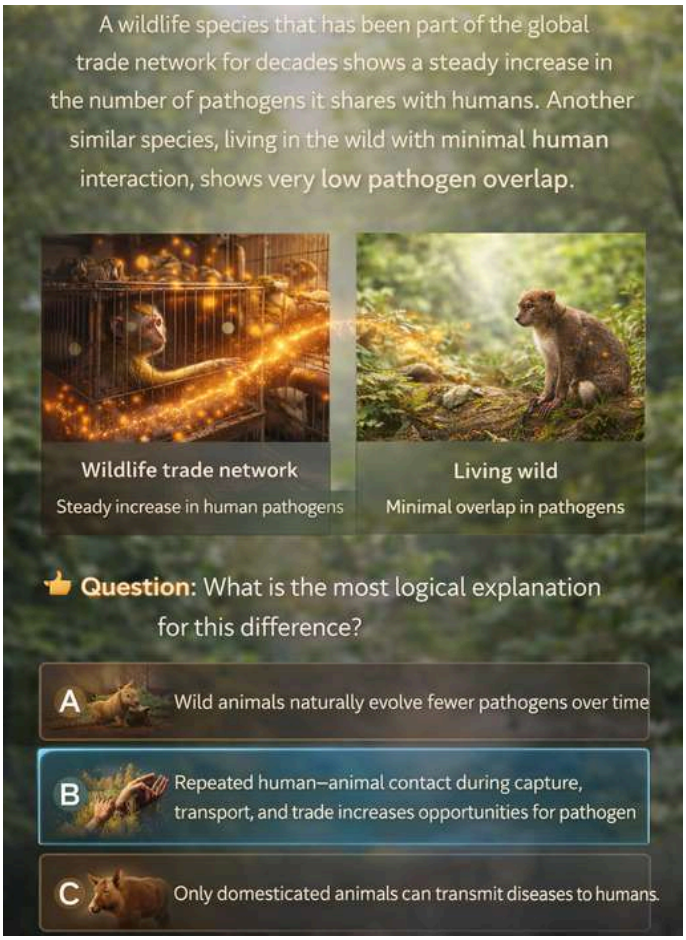
To understand the real-world situation, Elise took the team to a wildlife market. They saw animals packed closely, birds, mammals, and reptiles sharing limited space. People moved between cages, touching animals without protection. Everything looked normal at first glance, but Julien could now see what others could not. In such environments, pathogens can easily move between animals and eventually to humans. Stress in animals weakens their immune systems, increasing pathogen shedding, while poor hygiene further amplifies the risk. Claire noted that live-animal markets are especially risky because animals are alive, stressed, and constantly interacting.

Back in the lab, the team compared different types of trade and found that live-animal markets showed higher risks. They also considered illegal wildlife trade, which often operates without proper hygiene or health checks. Although harder to study, it clearly added another layer of danger. Julien realized the issue was not just the existence of wildlife trade, but the conditions under which it occurs. Weak regulation, lack of monitoring, and rapid transport systems allow diseases to spread silently across regions before they are even detected.

As the team prepared their findings, Julien wanted their message to be clear. He explained this is not about blaming animals, but understanding human behaviour. The more humans interact with wildlife through trade, the more opportunities are created for diseases to emerge. Claire emphasized better monitoring, stricter regulations, and reducing illegal trade. Adrian added that improving hygiene, surveillance systems, and public awareness in markets would also help reduce risks. Elise pointed out that global cooperation would be essential, as diseases do not respect national borders.

Months later, as their research reached the scientific community, Julien reflected quietly by the river in Fribourg. He realized that diseases do not appear out of nowhere they are built over time through repeated contact between species. Wildlife trade, he thought, is like an invisible bridge connecting animals and humans. With every interaction, that bridge becomes stronger, allowing unseen pathogens to cross more easily.

Looking at the calm water, Julien understood something important. Preventing future outbreaks is not just about reacting to diseases, but about recognizing and reducing the hidden risks that create them. And sometimes, the most dangerous threats are the ones we cannot see but continue to build through our everyday actions.



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| EXPERT OPINION |

MATERNAL HIV AND THE GUT MICROBIOME OF MOTHERS AND INFANTS: INSIGHTS FROM THE PRACHITI COHORT STUDY

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Inside every human gut live trillions of bacteria that are for the most part beneficial to our health. These microbes, collectively known as the gut microbiome, play an essential role in digestion, immunity, and overall well-being. In recent years, the gut microbiome has become a rapidly evolving area of scientific research, as we continue to discover its critical role in human health, disease, and metabolism. This is particularly important for populations with weakened immune systems, including individuals living with HIV, as well as those with altered or developing immune systems for pregnant women and their infants, respectively. We have conducted research in India on how immunocompromising conditions such as anemia and HIV may shape the gut microbiome and contribute to poor health outcomes. By studying these interactions, particularly in resource-limited settings like India, we aim to identify ways to prevent adverse health outcomes and improve the well-being of vulnerable populations with these conditions.

> *"The gut microbiome is not just a collection of bacteria, it is a powerful system that shapes immunity, metabolism, and health across generations."*

This research is an example of a successful Indo-US collaboration of institutions and investigators. We are based out of the Department of Epidemiology at Columbia University and our other US collaborators included those from Johns Hopkins University (JHU), Cornell University and University of Maryland, Baltimore. Our Indian collaborators were from Byramjee Jeejeebhoy government medical college (BJGMC) and the BJGMC-JHU clinical research site.

In our recent work published in Nature Communications (Mandell and Wang et al., Nat Comm 17, 3097 (2026)), we analyzed data from the PRACHITi (Pregnancy Associated Changes in Tuberculosis Immunology) cohort study in Pune, India. This was a cohort of pregnant women living with and without HIV that were enrolled at BJGMC, and we followed the mothers from pregnancy through 1 year postpartum, along with their children. In this study, we

sought to understand the influence of HIV infection on the gut microbiome and metabolome in mothers and their infants. Globally, millions of women of reproductive age are living with HIV, with the highest burden in resource-limited settings where there are high rates of maternal morbidity and mortality due to HIV. During pregnancy, HIV infection is associated with an increased risk of adverse birth outcomes such as preterm birth and low birth weight. In addition, children who are HIV-exposed uninfected (CHEU)–meaning they are born to mothers living with HIV but do not acquire the virus themselves–face higher risks of mortality, infections, poor growth, and developmental challenges compared to children born to mothers without HIV–children who are HIV-unexposed uninfected (CHUU). We believe that understanding how maternal HIV affects the gut microbiome of both mothers and their infants may identify specific microbes that contribute to these adverse health outcomes and could be critical to identify interventions to reduce infectious morbidity and mortality in these vulnerable populations.

The impact of HIV infection on the gut microbiome profile is a subject of ongoing study. HIV affects not only the immune system throughout the body but also the immune cells in the gastrointestinal tract. As a result, the balance of microbes in the gut could be disrupted, a condition known as gut dysbiosis, which can trigger inflammation and metabolic changes that contribute to adverse health outcomes. These disruptions in the gut microbiome may suggest potential biological pathways through which maternal HIV infection affects both maternal and infant health. In our cohort, we observed gut dysbiosis and distinct metabolomic profiles among women with HIV (WHIV) compared with seronegative (SN) women, and their infants. Several gut bacteria were differentially abundant by HIV status, and some of these bacteria are known to increase inflammation and adverse birth outcomes such as preterm birth and low birth weight. Together, our findings suggest that changes in the microbiome profile may play an important role in shaping health outcomes and may help explain persistent disparities observed among HIV-exposed populations.

> *Understanding how HIV alters the gut microbiome in mothers and infants can open new pathways to improve health, reduce risks, and protect future generations.*

The genus *Fusobacterium* stood out in our analysis, showing higher abundance among WHIV in their second and third trimesters. This was noteworthy to us as Fusobacterium has previously been linked to preterm birth in the oral, vaginal, and placental microbiomes, as well as to reduced immune recovery and dysfunction among individuals living with HIV. Yet, its role within the gut microbiome, especially among pregnant women with HIV, remains less clear. Its presence may represent a potential pathway linking HIV-associated microbial dysbiosis to adverse health outcomes. This raised another important question for us: how could the changes we found in the microbiota be linked to the systemic metabolome? In turn, it led us to conducting a multi-omics approach to better understand whether pathways may be shared between microbes and metabolites. We observed Fusobacterium was correlated with metabolites such as 2-hydroxyglutarate, suggesting shifts in glutamine and glutamate metabolism that may subsequently impact immunity and neurotoxicity. These results highlight the connection between the gut microbiome and metabolism, suggesting microbial and metabolic disruptions may jointly contribute to inflammation and other adverse conditions. This points to a larger role for microbiome-metabolome interactions in shaping maternal and infant health in the context of pregnancy and HIV.

| EXPERT OPINION |

Another striking finding of ours was the differential presence of bacteria from the Lachnospiraceae family in CHEU. These bacteria have been linked to promoting regulatory T-cell differentiation, a type of immune cell that suppresses the activation and proliferation of other T cells, which may limit CHEU's ability to respond effectively to infections. They have also been associated with gut dysbiosis and immune activation in infants. These findings suggest that the presence of specific microbial communities may impact long-term health outcomes in CHEU. This population could benefit from carefully tested interventions aimed at supporting the growth of beneficial bacteria that reduce the risk of infectious morbidity and other adverse health conditions.

Although research on the maternal-infant microbiome is still limited, it represents a promising and rapidly expanding field, particularly in India with its own distinct microbiome profile, with important implications for improving maternal and infant health outcomes. Pregnancy is a critical period for shaping both maternal and infant health trajectories, making it an important target for future interventions. We believe this work introduces a new direction for exploring whether approaches such as probiotics, prebiotics, or dietary modifications could improve outcomes during pregnancy. At the same time, integrating multi-omics approaches will be key to understanding how the microbiome interacts with the systematic metabolome and immune function. In countries like India, where microbiome research is a growing field, further focus on maternal-infant populations may offer new insight into underlying biological pathways for many diseases and their connection to the gut microbiome. Advancing research in this field could help inform new prevention and treatment strategies that support healthier pregnancies, improve birth outcomes, and promote early childhood development. Ultimately, these efforts have the potential to reduce the global burden of disease and mortality, particularly in resource-limited settings where maternal and infant health risks remain disproportionately high.

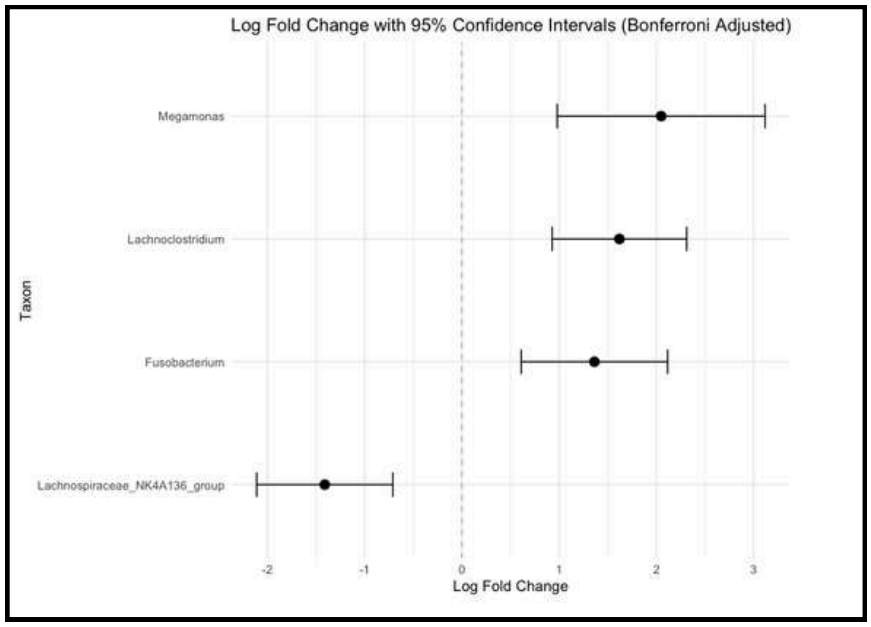

Figure: Differences in the abundance of gut bacteria at the genus level during the second and third trimesters by HIV status: Gut bacteria differed between pregnant women with HIV (WHIV) and those seronegative (SN) for HIV during the second and third trimesters. The plot shows which bacteria groups were higher (right of zero) or lower (left of zero) in pregnant WHIV after adjusting for age, mid-upper arm circumference (MUAC), and education.

For young researchers, the maternal-infant microbiome represents a compelling scope of research to explore. Despite recent advances, gaps remain in our understanding of how microbial, metabolic, and immune pathways interact during pregnancy and postpartum, particularly in populations affected by HIV or similar conditions. We believe some of the most important strategies young scientists must embrace to address these challenges include interdisciplinary approaches, innovative study designs, and studying diverse populations. We encourage those whose curiosity has been sparked by this research to explore this growing field. By contributing to microbiome studies, the next generation of researchers can have the opportunity to advance scientific understanding in an exciting field and help develop interventions that modify the gut microbiome and metabolome to improve health outcomes for both mothers and infants in India and around the world.

Dr. Shivakoti's and Dr. Mandell's contributions to this field are reflected in their publication in Nature Communication.
https://doi.org/10.1038/s41467-026-69912-0

| EXPERT OPINION |

A HIDDEN SWITCH THAT CONTROLS OUR BODY SLEEP-WAKE CYCLE

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| Scientific Profile | | Organization Link | | Research Lab Page | | Factors Press |

Areas of expertise: Biomolecular nuclear magnetic resonance spectroscopy | Conformational dynamics and function | Molecular biophysics of the circadian clock | Intrinsically disordered and metamorphic proteins

The rotation of the Earth around its own axis causes alternating periods of light and darkness and the 24-hour duration of this day-night cycle has remained approximately constant over several hundred million years. Life on Earth has learned to adapt to this day-night cycle through an internal clock called the circadian rhythm (from Latin: circa meaning around, and diem, a day) (Figure 1A). The circadian clock provides organisms with an evolutionary advantage by allowing them to anticipate the onset of light and darkness rather than merely respond to changes in illumination. We most commonly perceive the existence of this clock in our day-to-day life through jetlag, which occurs when we travel across time zones and throw the clock out of synchrony. An important property of the circadian clock is that it can be entrained by external cues such as light and temperature (known as Zeitgebers, German for time-givers), which is why jetlag disappears once our body has accustomed itself to the new time zone. The discovery of the molecular gears that keep the clock ticking was honoured by the 2017 Nobel Prize in Physiology or Medicine awarded to Jeffrey C. Hall, Michael Rosbash, and Michael W. Young. Somewhat alarmingly, disruption of the circadian clock because of ever-increasing shift work, as well as widespread exposure to low levels of light at night, has been linked to a range of maladies such as cardiovascular disease and cancer. There is thus an urgent need to understand the clock using both bottom-up and top-down research strategies.

> *"Our body's internal clock runs on a delicate balance of molecular interactions, where tiny changes in protein behavior can shape the rhythm of life."*

Our laboratory at the Molecular Biophysics Unit in IISc Bangalore studies biological systems where the jiggling and wiggling of molecules (referred to as dynamics), and not merely their shape (their structure), is important for carrying out function. Since the inception of the lab in November 2017, we have been keenly interested in the circadian clock, because the spatial and temporal choreography of the various protein molecules constituting the circadian clock is vital for maintaining its approximately 24-hour periodicity. The core circadian oscillator is made up of four proteins, PER2, BMAL1, CRY1 and CLOCK. We chose to initially focus on PER2, because it is partially structured and partially disordered, and its lifetime inside the cell is critical in setting the 24-hour time period of the circadian clock. The lifetime of PER2 is, in turn, controlled by the presence or absence of phosphoryl groups on serine residues located at the boundary of the ordered and disordered regions. Once the phosphoryl group gets attached (through an enzyme-catalysed process called phosphorylation), it becomes easier to degrade PER2, although why this must be so is not clear.

In 2019, Ms. Diksha Sharma, a project assistant in the lab, made the serendipitous discovery that PER2 does not exist in isolat-

ion, but instead forms large assemblies (called oligomers), each containing ~30 PER2 molecules, that could be visualized under an electron microscope. This observation led us to formulate an exciting hypothesis – that the serines which had to be phosphorylated are buried inside the oligomer. Once the serines get phosphorylated, the negative charges on the phosphoryl group are thrown in close proximity to each other and repel each other to break the oligomer apart. The smaller pieces would then degraded by the cellular machinery. Although this hypothesis gave us a way to explain why it was easier for the cell to degrade phosphorylated PER2, it raised as many questions as it answered – if PER2 oligomers protected the sites of phosphorylation, how would PER2 get phosphorylated in the first place? Would a single phosphorylation be enough, or would multiple serines have to get phosphorylated before the oligomer disintegrated?

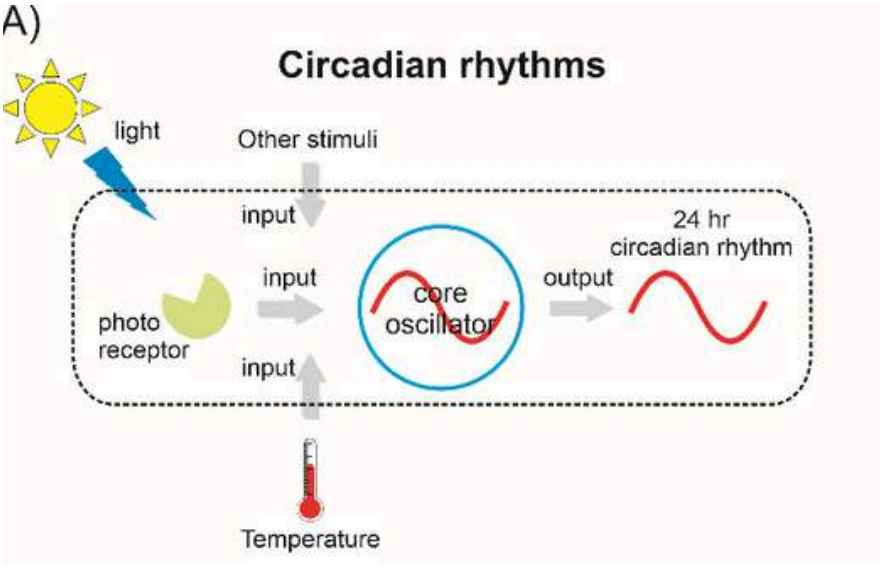
In 2020, Ms Paulomi Sanyal, a talented doctoral student, took over this challenging project and it required all her tenacity and perseverance to bring it to fruition. Our laboratory has traditionally used nuclear magnetic resonance spectroscopy (NMR, a method closely related to magnetic resonance imaging) to characterize the dynamics of biomolecules and study their impact on function. However, Paulomi recognized the value of integrating information from several biophysical methods such as light scattering, analytical size-exclusion chromatography, circular dichroism, fluorescence, thermodynamic analysis, NMR spectroscopy and electron microscopy to tackle the complexity that accompanied the questions we had posed.

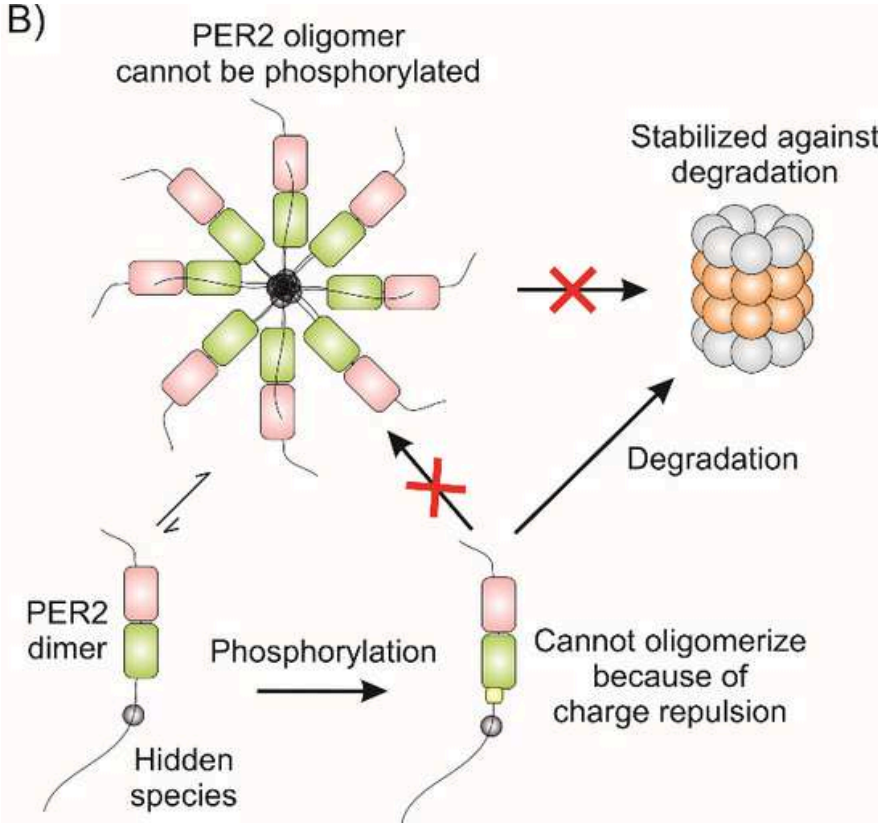
The outcome of this effort is a unified molecular model for how phosphorylation of PER2 modulates circadian timekeeping (Figure 1B). PER2 forms large oligomers and the stability of the oligomer derives from cooperativity between the structured and the disordered regions. The region that is phosphorylated is protected within the oligomer and cannot be phosphorylated, with the result that PER2 is stabilized and its lifetime in the cell increases. Crucially, there is also a small hidden population of PER2 that is dimeric (i.e. each dimer contains only two molecules of PER2), and PER2 molecules can efficiently jump back and forth between dimeric and oligomeric forms. It is this dimer that is phosphorylated and eventually targeted for degradation. Assemblies formed from phosphorylated PER2 are much less stable and systematically reduce in size as the amount of negative charge per PER2 increases. The consequence is a two-way bidirectional switch where oligomerization prevents phosphorylation and the addition of phosphate groups destabilizes the oligomer. The balance between these two opposing driving forces eventually controls the cellular lifetime of PER2 and thereby influences the circadian time period. It is noteworthy that this switch hinges on an 'invisible' dimeric state of PER2, highlighting the importance of characterizing these latent states in order to understand function in its entirety.

> *"From hidden protein states to dynamic molecular switches, the circadian clock reveals how life keeps time at the smallest scale."*

One of the quintessential goals of biophysics is to explain biological function from a molecular perspective. The conclusions which emerge from our work accomplish this by explaining why phosphorylation 'destabilizes' PER2 and pushing the boundaries of our understanding of the molecular mechanism controlling the circadian clock. The results link structural polymorphism in PER2 to post-translational modifications (a broad term that encompasses chemical changes to a protein after its synthesis or translation) and identify a bidirectional molecular switch that dynamically regulates the circadian period. Exciting recent work from other labs across the world have also demonstrated the existence of large assemblies containing PER2 inside living cells, bridging our 'test tube' science with the behaviour of living organisms.

| EXPERT OPINION |





During this work, we had the pleasure of working alongside Prof. Carrie Partch, a world leader in the biophysics of the circadian clock, and her team from the University of California Santa Cruz. Ms. Diksha Sharma, who began her adventures into the circadian clock with us, is currently a doctoral student in the Partch lab.

We are also grateful to the generous and flexible funding provided by the DBT/Wellcome Trust India Alliance for this work and to Prof. Jayant Udgaonkar from IISER Pune for encouraging us to persevere with this project.

Dr. Sekhar's contributions to this field are reflected in his publication in *Proceedings of the National Academy of Sciences (PNAS)* (2026). https://doi.org/10.1073/pnas.2525373123

Figure *A) The circadian clock in mammals generates ~24 hour rhythms and can be entrained by environmental cues such as light. B) The model emerging from our work for the bidirectional switch that connects phosphorylation with structural polymorphism to dynamically control PER2 stability and regulate circadian period.*

| EXPERT OPINION |

HOW 3D BIOPRINTING COULD CHANGE THE FUTURE OF MEDICINE

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Area of expertise: 3D Bioprinting | In vitro disease models | Biomedical Device Coatings | Immunomodulatory Biomaterials | Bioinspiration

Modern medicine has transformed the way we treat disease, repair tissues, and extend human life. Yet, one fundamental challenge persists: our limited ability to fully restore or replace damaged human tissues and organs. From the global shortage of donor organs to the constraints of synthetic implants, there is a growing need for solutions that go beyond treatment and move toward true regeneration. In this context, 3D bioprinting is emerging as a powerful technology that could redefine the future of healthcare.At its core, 3D bioprinting is an advanced biofabrication approach that enables the precise placement of living cells, biomaterials, and biological signals in a layer-by-layer manner to create tissue-like structures. Unlike conventional 3D printing, which uses plastics or metals, bioprinting relies on "bioinks" which are engineered materials that mimic the natural cellular environment. Over time, these bioprinted constructs can mature into tissue-like systems, offering a unique platform to replicate aspects of human biology outside the body.

One of the most promising applications of 3D bioprinting lies in tissue engineering and regenerative medicine. Researchers are already developing bioprinted skin for wound healing and cartilage constructs for joint repair. Looking ahead, the ability to fabricate patient-specific tissues using a patient's own cells could significantly reduce dependence on donor organs and minimize immune rejection.

> *"3D bioprinting is evolving from structural fabrication toward intelligent, immune-integrated, and clinically translatable living systems."*

This represents a shift toward personalized regenerative therapies, where treatments are tailored to individual patients rather than standardized across populations.

Beyond transplantation, 3D bioprinting is also transforming drug discovery and disease modeling. Traditional testing systems often fail to capture the complexity of human physiology, contributing to high failure rates in clinical trials. Bioprinted tissues provide a more physiologically relevant alternative, enabling researchers to study disease progression and evaluate therapies in realistic environments. Notably, regulatory developments such as the FDA Modernization Act 2.0 (2022), which removed the mandatory requirement for animal testing, along with subsequent legislative efforts under the proposed FDA Modernization Act 3.0, are accelerating the adoption of human-relevant nonclinical models, including organoids, microphysiological systems, and emerging bioprinted platforms. Advances in high-throughput biofabrication are particularly significant in this context. Recent studies have demonstrated integrated platforms capable of rapidly organizing cellular building blocks with high precision and viability, significantly accelerating tissue fabrication while maintaining functional integrity (Singh et al., Bioactive Materials, 2025; Nature Communications, 2024). Such developments are helping bridge the gap between laboratory research and scalable, translational applications.

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Despite these advances, a critical challenge remains: ensuring that bioprinted tissues are not only structurally accurate but also functionally viable over time. Living tissues require vascular networks to supply oxygen and nutrients, and replicating this level of complexity remains a major scientific hurdle. Equally important is the interaction between engineered constructs and the host immune system, which ultimately determines whether an implant integrates successfully or fails.

To address this, the field is undergoing an important shift from designing materials that are simply biocompatible to developing systems that actively engage with biology. Immuno-engineering is emerging as a key strategy, where biomaterials are designed to guide immune responses toward healing and regeneration rather than inflammation or rejection. By incorporating bioactive signals such as extracellular vesicles, cytokines, or immune-modulatory polymers, bioprinted constructs can become active participants in the regenerative process rather than passive implants.

At the same time, the integration of artificial intelligence (AI) with bioprinting technologies is opening new frontiers. AI-driven systems can optimize printing parameters, monitor construct quality in real time, and improve reproducibility. Machine learning approaches are also being used to predict optimal fabrication conditions and design more efficient tissue systems, enabling a transition toward intelligent and adaptive biofabrication platforms (Advanced Functional Materials, 2025).

From an industry perspective, 3D bioprinting has already moved beyond a purely academic concept and is rapidly emerging as a translational sector. The global 3D bioprinting market size was valued at USD 2.3 billion in 2023 and is projected to reach USD 5.3 billion by 2030, growing at a CAGR of 12.5% from 2024 to 2030. This growth is driven by limited number of organ donors, increasing adoption in pharmaceutical research, personalized medicine, and advanced biomaterials development. Notably, the most commercially mature segment today includes drug-testing platforms, tissue models, and biofabrication tools, which are already delivering real-world value.

> *"The challenge is no longer to build tissues, but to design biology that can function, adapt, and truly belong."*

However, it is important to distinguish between 3D-printed medical devices, which are already widely used in clinical settings, and living bioprinted tissues, which present additional biological and regulatory challenges. The path to clinical translation for bioprinted systems is likely to follow a stepwise progression. Early applications such as skin substitutes, wound healing systems, and localized cartilage constructs are expected to reach broader clinical adoption in the late 2020s to early 2030s, supported by ongoing technological and clinical advancements. In contrast, more complex applications, particularly fully vascularized and functional organs, remain a longer-term goal. Based on current scientific and regulatory progress, such systems are more realistically expected in the mid-to-late 2030s or beyond.

Looking ahead, the future of 3D bioprinting will be defined by convergence. Advances in stem cell biology, biomaterials science, computational modeling, and engineering are coming together to enable increasingly sophisticated systems. Emerging technologies such as smart biomaterials, high-throughput platforms, and AI-driven biofabrication are pushing the field toward constructs that are not only structurally accurate but also functional, adaptive, and clinically translatable.

For young researchers and students, this field offers an exciting opportunity to contribute to meaningful healthcare innovation. 3D bioprinting is inherently interdisciplinary, requiring expertise across biology, engineering, materials science, and data scien-

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ce. Future progress will depend on problem-driven research, identifying real clinical challenges and developing solutions that are scalable, affordable, and translatable. Equally important is an understanding of regulatory pathways and clinical needs, which are essential for bridging the gap between innovation and real-world impact.

In conclusion, 3D bioprinting represents a powerful convergence of engineering and biology with the potential to transform modern medicine. While significant challenges remain, advances in high-throughput biofabrication, immune engineering, and intelligent systems are steadily bringing this vision closer to reality. The future of medicine will not be defined solely by our ability to treat disease, but by our ability to engineer living systems that restore, regenerate, and integrate seamlessly within the human body.

> *The challenge is no longer to build tissues, but to design biology that can function, adapt, and truly belong.*

Dr. Singh's contributions to this field are reflected in his publication in Bioactive Materials (2026), 10.1016/j.bioactmat.2025.11.024 , Nature communications (2024) https://doi.org/10.1038/s41467-024-54504-7 and Advanced Functional Materials (2026) https://doi.org/10.1002/adfm.202509530

| EXPERT OPINION |

HOW TINY MATERIALS CAN ACT LIKE ENZYMES

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| Scientific Profile | | Organization Link | | Research Lab Page | | Factors Press |

Areas of Expertise: Nanocomposite and Nanozymes | Biomaterials | Sensor Development | Catalysis and Materials Chemistry

Nanozymes: From Enzyme Mimicry to Real-World Applications: The groundbreaking discovery of intrinsic peroxidase activity (POD) for ferromagnetic nanoparticles reported in Nature Nanotechnology has led to a huge increase in research on artificial nanozymes over the past few decades. However, a fundamental question remains: How did the concept of "nanozymes" gain popularity in the scientific community, and what is the underlying mechanism that enables these tiny nanozymes to replicate the catalytic behaviour of natural enzymes?

The term "nanozymes" refers to nanomaterials that mimic the catalytic function of natural enzymes, such as Horseradish peroxidase, by providing a high surface-active site, including a metal centre, a defect, or edge sites, where the substrate can adsorb and undergo catalytic transformation. Similar to the natural enzymes, these artificial enzymes primarily operate through an electron transfer mechanism. Artificial nanozymes, particularly those on metal-based surfaces like Fe, Cu, or Ni, facilitate redox reaction by undergoing a reversible change in oxidation state (e.g., Fe^{2+}/Fe^{3+}, Cu^{+}/Cu^{2+}), therefore enabling electron transfer efficiently. This reversible redox behaviour triggers their enzyme-mimicking activity, allowing their use as a catalyze the reactions such as H_2O_2 decomposition, generation of reactive oxygen species. These highly reactive intermediates are unstable and subsequently oxidize the target substrate, such as TMB/OPD. The oxidation of these substrates can be monitored by observing the color change of the oxidized product. This colorimetric sensing strategy serves as the foundation for the detection of a wide range of biomolecules and heavy metals. The catalytic efficiency of these nanozymes in comparison to natural enzymes can be quantitatively measured using the Michaelis-Menten kinetics. The key Michaelis-Menten parameters, such as Michaelis constant (Km), maximum reaction velocity (Vmax), and turnover number (Kcat), provide insight into substrate affinity, catalytic capacity, and overall enzymatic performance. Artificial nanozymes offer the advantage of tunability of their physicochemical properties, such as size, shape, and composition, enabling optimization of their catalytic performance. Although these artificial nanozymes generally offer lower substrate specificity than natural enzymes, they offer significant advantages such as superior stability, cost-effectiveness, and the ability to work under harsh conditions. These advantages make them a promising candidate for a wide range of applications, including chemical sensing, environmental remediation, and biomedicine.

> "Nanozymes show that tiny materials can perform powerful chemistry mimicking nature while working stronger, faster, and in tougher conditions."

Types of Nanozymes: The nanozymes can basically be categorized into four classes based on their enzyme-mimicking behaviour.

(I). Type I nanozymes, termed as "active site centre mimic", include transition metal compounds such as Fe_3O_4, MnO_2, $CuSe_2$, $FeSe_2$, Cu_2Te, etc., which imitate natural enzyme active sites.

(II). Type II, known as "Functional mimic," consists of metal nanoparticles (e.g., Au, Ag, Pt, Pd, Ir) and carbon-based nanomaterials like graphene oxide, fullerene, and carbon quantum dots.

(III). Type III nanozymes are "nanocomposites" combining the features of both Type I and Type

II materials, including hybrid and metal-organic framework (MOFs), to enhance catalytic performance.
(IV). Finally, type IV nanozymes are "3D structural mimics," such as single-atom nanozymes and bimetallic alloys with etched channels, designed to replicate the structural complexity and efficiency of natural enzymes.

Fe, V, metal, and MOF-based nanomaterials exhibit POD; Cu, Mo, and Pt-based nanomaterials act as oxidase mimics; metal, metal oxide, Pt, and Pd-based nanomaterials function as catalase mimics; carbon, Ce, and melanin-based nanomaterials also showed catalase-like mimic behavior; while carbon-based, monolayer-functionalized gold nanoparticle, and MOF-based nanomaterials mimic hydrolase activity.

Our group focuses on the rational design and synthesis of metal-based nanozymes and 2D material–doped metal nanozymes that effectively mimic the catalytic activity of peroxidase enzymes, enabling enhanced reactive oxygen species generation and efficient catalytic degradation process. We have developed Cu2Te, FeSe2, and their respective composite such as Cu2Te/rGO and FeSe2/rGO, which exhibited strong peroxidase and catalytic-like behaviour. We have also shown that the combination of Cu2Te/rGO or FeSe2/rGO showed enhanced POD as compared to their pristine Cu2Te or FeSe2 NPs. The catalytic mechanism of these nanohybrids can be generalized as a synergistic nanozymes system for substrate oxidation, particularly for substrates such as TMB and OPD. In this system, the metal in the pristine component undergoes a redox cycle, which activates H2O2 through a Fenton-like pathway, to generate highly reactive •OH radicals, primarily responsible for oxidation. The presence of a reducing environment facilitates the formation of Cu+, thereby enhancing •OH radicals' generation and catalytic turnover. Simultaneously, the rGO matrix plays a significant role for the enhance POD catalytic activity by accelerating electron transfer and stabilizing the intermediate state. The •OH radical generated during the reaction oxidizes the TMB/OPD substrate into its respective oxidized product, leading to visible colorimetric detection. Additionally, pristine nanoparticles are uniformly dispersed over the rGO surface owing to the strong interfacial interaction, thereby increasing the accessibility of more active sites and facilitating efficient substrate adsorption in the proximity to the catalytic centre. Overall, the synergistic combination between redox-active pristine nanoparticles and conducting rGO surface results in the efficient electron transfer, increased ROS generation, and superior POD activity via the oxidation of TMB/OPD.

> "From cleaning pollution to detecting diseases, nanozymes turn invisible reactions into real-world solutions."

Furthermore, In our study, molecular docking analysis of the FeSe2/rGO nanohybrid revealed significantly enhanced binding affinities toward peroxidase-related proteins, including 1HRP (−9.9 kcal/mol), 1PRX (−11.3 kcal/mol), 2BOQ (−10.5 kcal/mol), 4W7J (−10.7 kcal/mol), 6IU1 (−11.9 kcal/mol), 6QZO (−10.2 kcal/mol), and 7QYO (−11.0 kcal/mol), compared to pristine FeSe2 nanoparticles, confirming stronger interactions and superior catalytic potential of the nanohybrid.

Future Prospective: The unique architecture of the nanomaterial contributes to the intrinsic POD catalytic behaviour, which can open up new doors for the development of a nanozyme-based platform for sensing, environmental, and biomedical applications. There are still some drawbacks, such as reproducibility, recyclability, specificity, and selectivity. These nanomaterial/nanohybrid can be functionalized/turned based on the selectivity and colorimetric biosensors for the detection of cysteine, glucose, H2O2, heavy metals, and cholesterol, etc. Integrating such nanozymes into portable sensing devices, paper-based strips, and microfluidic systems could enable them for real-time and on-site detection. One can study the underlying mechanism using advanced spectroscopic and computational stu-

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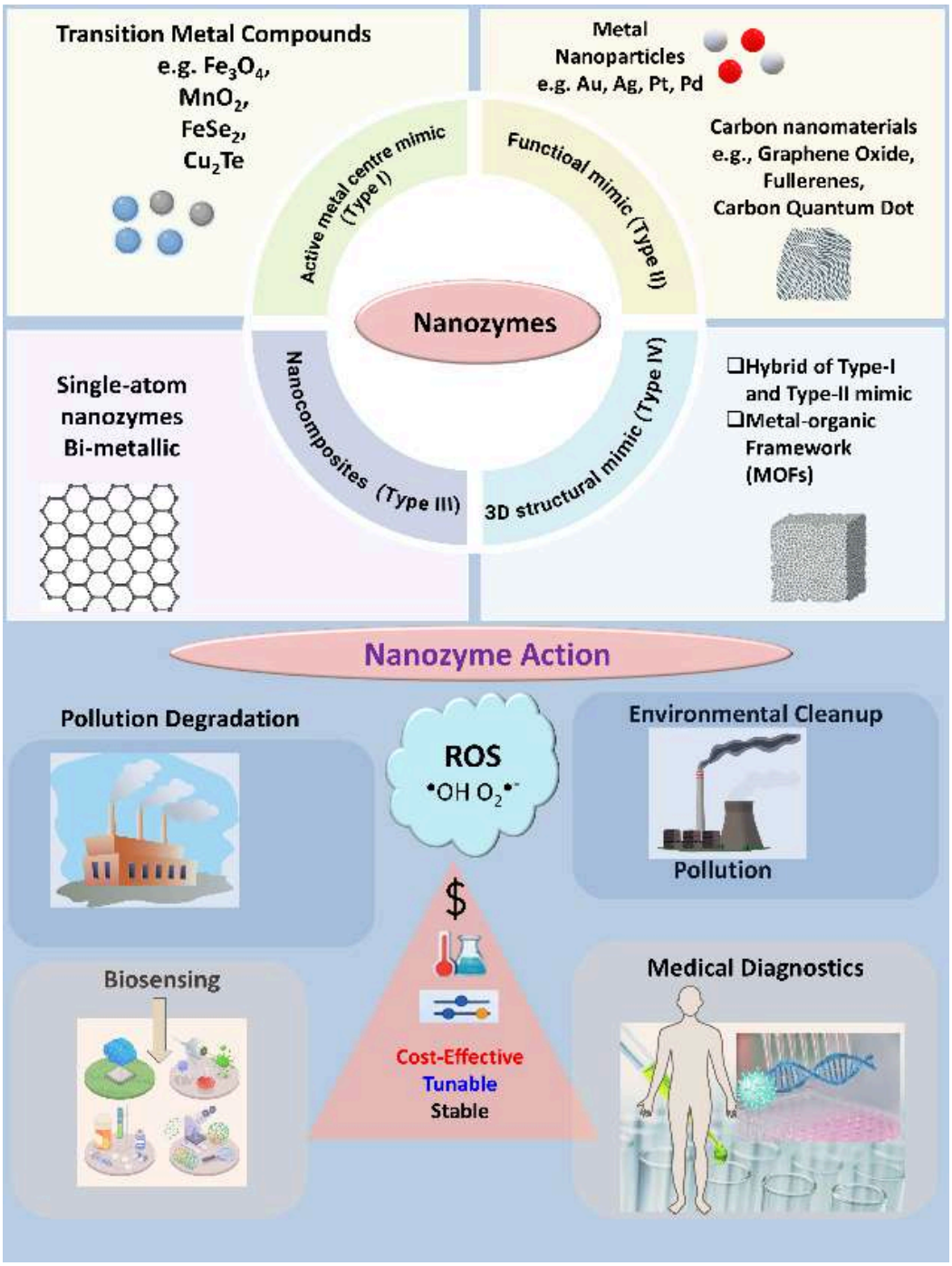
dies, which can provide more details regarding the electron transfer process and active site behaviour.

Artificial intelligence and machine learning could play a vital role in screening the selectivity towards a particular target. Furthermore, one can study the biocompatibility/ stability experiment, which can open up new doors in the biomedical area, such as diagnostic, imaging, and therapeutic applications, including ROS-mediated antibacterial or anticancer strategies. Overall, this work lays a strong foundation for the scalable development of cost-effective, robust, and multifunctional nanozyme systems with board interdisciplinary approach.

Thus, nanozymes offer a unique platform that integrates enzymatic efficiency with material stability, paving the way for the next-generation catalytic system.

Dr. Chalana's contributions to this field are reflected in his publication in ACS Applied Bio Materials https://pubs.acs.org/doi/10.1021/acsabm.5c02541 and ChemistrySelect, https://doi.org/10.1002/slct.202304361



Nanozymes-Mediated Process, highlighting their multifunctional applications through the catalytic process.

| EXPERT OPINION |

A SMART MATERIAL THAT CHANGES ITS GLOW TO DETECT CHEMICALS

Prof. Debdas Ray
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| Scientific Profile | | Organization Link | | Research Lab Page | | Factors Press |

Areas of Expertise: Triplet Energy Harvesting | Energy Conversion | Photosensitizer | Sensing

When we think about chemical sensing, we often imagine a device that gives a digital readout or a test strip that changes color. But chemistry is now moving toward something far more elegant: materials that can respond to their surroundings by changing the way they emit light. In the recent Communications Chemistry article, "A state-switchable TADF macrocycle for multi-analyte sensing and hydrogen gas-driven emission enhancement," researchers describe exactly such a system: a smart molecular material that can alter its glowing behavior depending on which chemical species it encounters.

What makes this work especially exciting is that the material does not simply become brighter or dimmer in a routine way. It can switch between different emission states. That means its light output is not fixed. Instead, it is adaptive, almost conversational. Different chemical guests push the molecule into different photophysical modes, and those changes can be read out through shifts in brightness, color, and delayed light emission. In a world that increasingly needs fast, sensitive, and selective detection technologies, this is a powerful idea.

The central material in the study is called CPCQ. It is a macrocycle, meaning a large cylindrical-shaped molecule, built from four twisted donor–acceptor units arranged in a cyclic architecture. That ring-like structure matters. In many light-emitting molecules, the chromophore, the light-producing part, is treated as a more or less fixed object. Here, the cyclic design creates a cooperative platform in which multiple emitting units can work together. The result is a material with strong baseline performance even before sensing begins: it shows a photoluminescence quantum yield of 78%, a delayed lifetime of 243 nanoseconds, and a reverse intersystem crossing rate of $2.68 \times 10^7\ s^{-1}$. In plain terms, it is already an efficient glow-emitter, and it is unusually good at managing excited states in a controlled way.

> "This smart molecule doesn't just glow it changes its light to 'tell' us what chemical is present, turning light into a language of detection."

To understand why this matters, it helps to unpack one key term: TADF or thermally activated delayed fluorescence. In ordinary fluorescence, a molecule absorbs energy and quickly emits light. In TADF materials, some of that energy temporarily enters a darker triplet state before being thermally recycled back into a light-emitting singlet state. That recycling can improve efficiency because energy that might otherwise be lost is recovered as light. TADF has already become important in advanced display technology and organic light-emitting devices. What this paper shows is that TADF can also be turned into a sensing strategy.

That is the real conceptual leap. Most sensors are designed to recognize one target and give one kind of signal. CPCQ behaves more like a photonic decision-maker. Electron-deficient guests cause it to form exciplexes, which reduce fluorescence and shift the emission.

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Electron-rich guests do something different: they enhance delayed fluorescence through what chemists call the heavy atom effect. Oxygen produces yet another response by quenching charge-transfer emission and restoring a blue-shifted locally excited state. Then comes the most striking result of all: hydrogen not only changes the emission state but boosts the locally excited emission dramatically, giving a radiative rate of 2.07 × 10^8 s^{-1} and a photoluminescence quantum yield of 93%.

This matters because each of these chemicals leaves a distinct optical fingerprint. The material does not merely say "something is present." It says, in effect, "this type of guest is here, and I will respond in this particular way." That is what scientists mean by multi-analyte sensing. A single material can detect multiple classes of chemicals by producing different optical outputs. For practical applications, that is a major advantage. Instead of building separate sensors for each target, one can imagine integrated sensing platforms based on one adaptable molecular system.

> *"From sensing hydrogen to identifying multiple chemicals, this material shows how molecules can move from passive emitters to active, intelligent sensors."*

Hydrogen sensing deserves special attention. Hydrogen is widely discussed as a clean energy carrier, but it is also highly flammable and difficult to detect because it is colorless and odorless. Reliable hydrogen sensing is therefore essential in storage, transport, and fuel technologies. In this study, hydrogen triggers a particularly strong enhancement in emission rather than simple quenching. That is useful because a signal that becomes brighter can be easier to detect against background noise than one that merely fades. A molecule that turns on more strongly in the presence of hydrogen could therefore be valuable in safety monitoring and next-generation energy systems.

Another notable aspect of the paper is its suggestion of superradiance-like behavior. The authors propose that the dramatic increase in locally excited emission under hydrogen may arise from cooperative action among the donor–acceptor units in the macrocycle. For a general reader, the important point is this: the molecule may be doing more than the sum of its parts. Its architecture allows several subunits to act together, producing a response that is amplified beyond what one might expect from a single isolated emitter. Even if future studies refine the mechanism, the broader lesson is already clear: smart function can emerge from collective molecular design. This work offers an important message about modern chemistry. Today's functional materials are rarely just "molecules" in the old static sense. They are information-rich systems. Their shapes, electronic structures, excited states, and host–guest interactions are all engineered together. This is chemistry meeting physics, materials science, and engineering in a single design. The best new molecules are not simply stable or beautiful; they are responsive, programmable, and purposeful. This study is also a compelling teaching example. It links textbook ideas such as fluorescence, excited states, charge transfer, host–guest chemistry, and molecular architecture to a real application with societal relevance. This highlights why investment in fundamental molecular research matters. A discovery that begins with an unusual light-emitting macrocycle can lead to practical tools for environmental monitoring, industrial safety, energy infrastructure, and optoelectronic devices. The pathway from basic science to application is often nonlinear, but this paper shows how quickly that bridge can become visible.

In my view, the most important contribution of this work is not only that it presents a new sensor. It presents a new design philosophy. Instead of asking a material to emit light in one optimized way, the researchers have built a system that can switch, adapt, and communicate through light. That is a profound shift. It moves us from passive luminescent materials to active photonic materials that respond intelligently to chemical surroundings.

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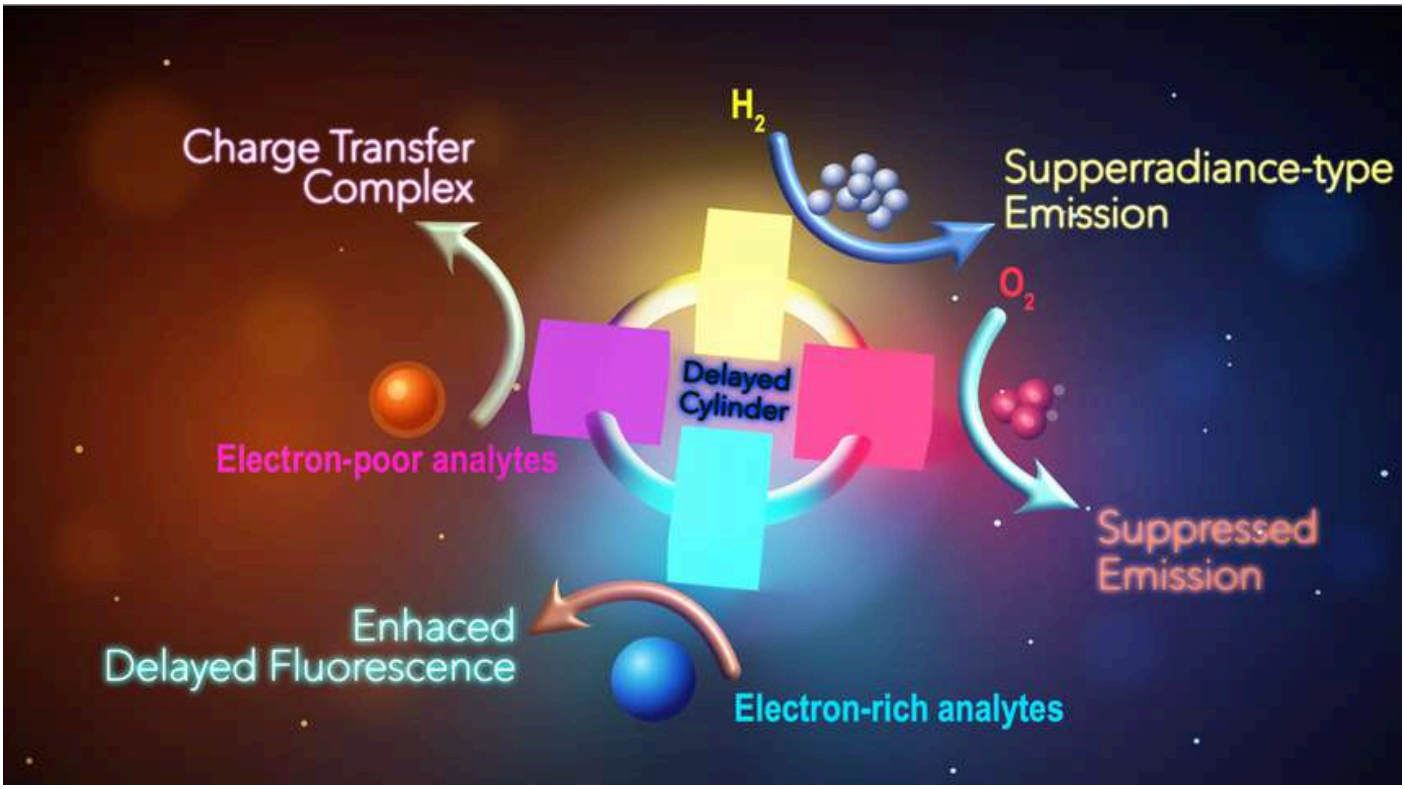

As chemistry advances, we will need more materials like this: compact, efficient, selective, and capable of reading the world around them through changes in light. CPCQ points in that direction. It shows that a carefully designed molecular ring can become a dynamic optical platform, sensitive to different analytes and especially promising for hydrogen detection. A smart glow may sound poetic, but in this case it is also practical science. And that is what makes this work so memorable: it turns molecular light into useful chemical language.

Prof. Ray's contributions to this field are reflected in his publication in Communication Chemistry (2026). https://doi.org/10.1038/s42004-026-01953-4

> *"From sensing hydrogen to identifying multiple chemicals, this material shows how molecules can move from passive emitters to active, intelligent sensors."*

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"WHY ORAL CANCER COMES BACK AND WHAT SCIENCE CAN DO NEXT?"

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| Scientific Profile | | Organization Link | | Research Lab Page | | Factors Press |

Area of Experties: Oral Cancer Biology | Cancer Stem Cells and Chemoresistance | Transcriptional Reprogramming in Cancer | Molecular Oncology and Multi-Omics Cancer Research

Why is cancer so hard to treat? This is a question that patients, families, and even doctors ask every single day. One of the most painful truths about cancer is that even after successful treatment after surgery, chemotherapy, or radiation the disease sometimes comes back. This recurrence or relapse is often more aggressive and far more difficult to treat than the original tumor.

But what exactly causes this recurrence? Why do some cancer cells manage to escape treatment and return months or even years later? These questions drive the core of the research in our laboratory, and today I want to take you through what we have discovered.

The Hidden Enemy: Dormant Cancer Cells: After treatment, most cancer cells die. But a small group often just a handful manage to survive. They may hide in our body for years in a dormant or "sleeping" state. During this time, they don't divide, they don't spread, and they don't trigger symptoms. They remain silent.

But eventually, something awakens them.

Scientifically, this awakening is referred to as the acquisition of self-renewal ability. In simpler terms, these dormant cells regain the ability to behave like stem cells cells that can divide endlessly and create new cancer cells. These cancer cells are generally called Cancer stem cells (CSCs). Once this switch turns on, recurrence becomes likely. Our lab focuses on what causes this switch. How do sleeping cancer cells reprogram themselves to start dividing again? What signals do they receive? And more importantly is it possible to block this process?

> "Cancer returns not because all cells survive, but because a few learn to hide, adapt, and awaken stronger than before."

The External Influence: How the Microenvironment influence cell behavior: One possibility is that the awakening comes from within the cancer cell itself its inherent properties. Another possibility is that it is triggered by signals from the environment where the cell is hiding. Though both mechanisms can contribute, now we will talk about the signals from the surroundings. Dormant cancer cells are influenced by their microenvironment, the surrounding cells, proteins, and chemical signals in the tissue where they hide. Normal cells constantly communicate with their neighbors through signaling pathways. One of these pathways is the Eph/Ephrin pathway, which involves interactions between a receptor (Eph) and its ligand (Ephrin).

Usually, this pathway mediates communication between two neighboring cells. When Eph and Ephrin interact across two different cells, signals are triggered in both. When neighboring cells interact, the ligand sends signal to the receptor and the receptor initiates a signaling cascade to bring about a function. This signaling downstream of the receptor is called "forward signaling". This is especially important in places like stem cell niches, where

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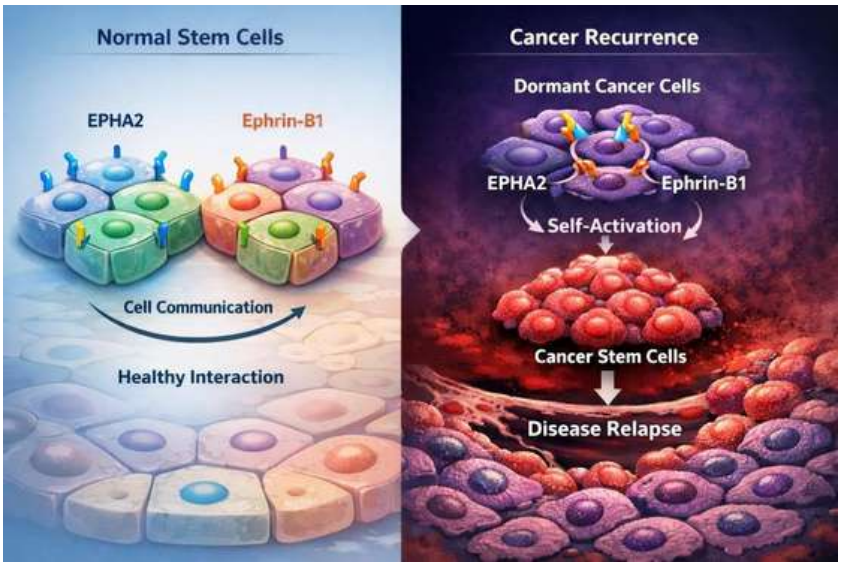
one cell remains dormant while its neighbor begins to differentiate. For example, EphrinB1 interacting with EphB1/2 helps regulate the maintenance and differentiation of intestinal stem cells.



Cancer is an Enigma: Apart from the regulation of normal stem cells, Eph/Ephrin pathway plays a role in cancer as well. When neighboring cells interact, the ligand sends signal to the receptor to initiate "forward signaling". Though this ligand-induced "forward signaling" suppresses cancer progression (by blocking proliferation and cell spread), the Eph receptors adopt alternate signaling mechanism to favor cancer progression- by interacting with other pathway receptors. Through this altered pathway or "noncanonical signaling", the receptors (Ephs) favor the progression of cancer by augmenting proliferation, vascularization and expanding cancer stem cell (CSC) pool.

The Ephrins on the other hand are considered to be suppressing cancer, as they initiate tumor suppressive "forward signaling". When we do experiments in lab, in a petri dish, we see that ligands inhibit cell proliferation and spread of the cancer cells. So, it should be limiting the growth of the cancer and spread of the disease. But, when we analyzed the role of this pathway in cancer, patients who had high expression of the ligand showed poor outcome, implying that the ligands are doing some other functions, favoring cancer progression.

> "When cancer cells begin to 'talk to themselves,' they unlock the power to renew, resist treatment, and drive recurrence."

What do the ligands do to worsen the cancer? This was a question that was not answered for a long time.

A Surprising Discovery: The Cancer Cell Talks to Itself: Our lab found something unexpected and intriguing. In the cancer cells that acquire self-renewal ability, the Eph/Ephrin interaction does not happen between two different cells. Instead, it occurs within the same cell.

This is unusual and not seen in normal cells or even in other types of cancer cells. Even more fascinating, the combination of receptor and ligand involved in this self-interaction is unique. We discovered that Ephrin-B1 interacts with EPHA2 within the same cancer cell to trigger self-renewal. This autocrine or "self-activating" signaling mechanism may be one of the key drivers of recurrence.

Origin of the Story: In our effort to understand how "sleeping" cancer cells wake up and become more aggressive, we studied the signals that control this process. These awakened cells can turn into cancer stem cells (CSCs) a small but powerful group of cells that can drive tumor growth and recurrence. To investigate this, we used advanced techniques like mass spectrometry to analyze proteins on the surface of cancer cells and the internal signaling pathways they use to communicate. Through this, we identified an important pathway called the Eph/Ephrin pathway, and in particular, a molecule called Ephrin-B1. Our early experiments with oral cancer cells suggested that two proteins EPHA2 (a receptor) and Ephrin-B1 (a ligand) play a key role in this process.

An Unusual Partnership: In many cancer cells, Ephrin-B1 is usually not present on the cell surface and hence not engaged in signaling.

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Meanwhile, EPHA2 is highly active through the "noncanonical signaling" promoting tumor growth, including proliferation and formation of new blood vessels. However, when the surrounding environment sends signals that encourage cancer cells to behave like stem cells, Ephrin-B1 moves to the cell surface. This allows it to interact with EPHA2. What makes this surprising is that these two proteins don't normally pair up. They belong to different subgroups, and typically, ligands and receptors interact within their own group. This unexpected pairing caught our attention.

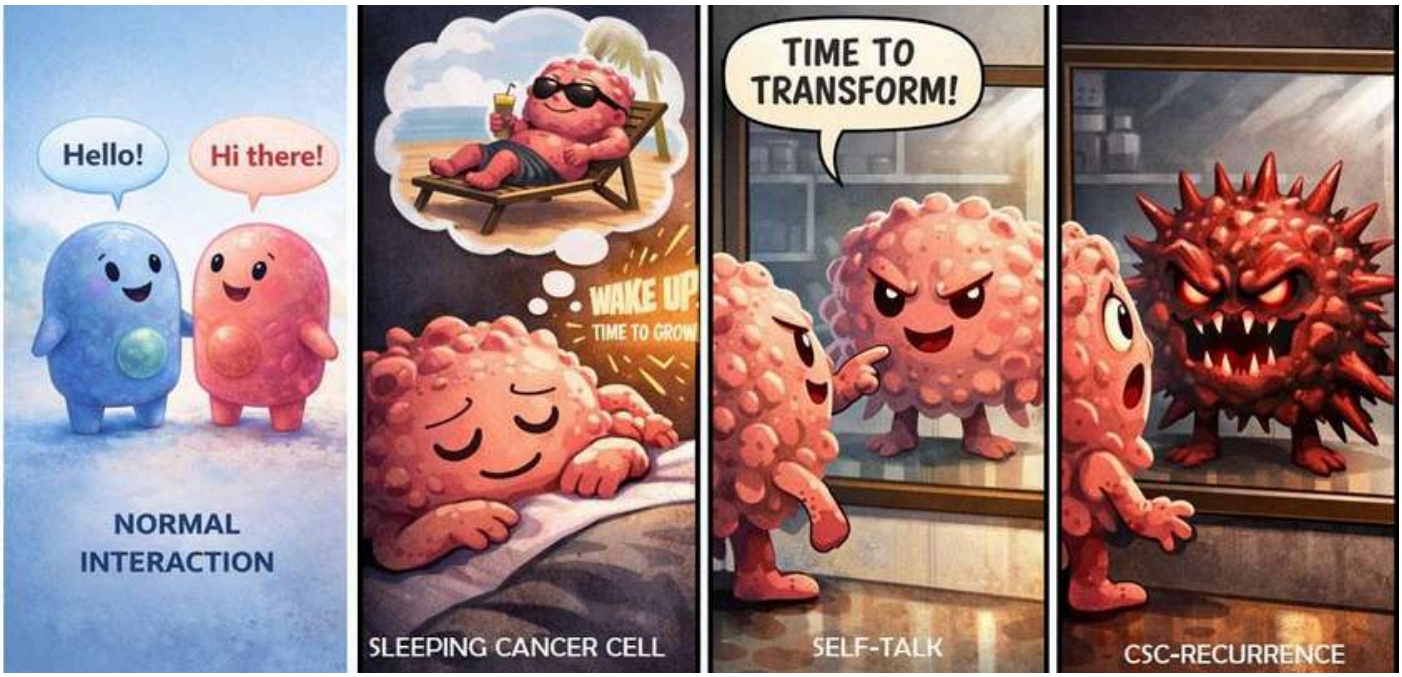
Proving the Interaction: To confirm that EPHA2 and Ephrin-B1 truly interact, we used several laboratory techniques (Co-immunoprecipitation, Proximity Ligation Assay, Foster Resonance Energy Transfer etc.) that allow us to detect close protein interactions inside cells. These experiments showed that the two proteins do indeed bind to each other and importantly, this happens within the same cell. We also found that this interaction plays a major role in increasing the number of cancer stem cells. We confirmed this using multiple experimental approaches, including studies in cell cultures, animal models, and samples from oral cancer patients.

"Self-Talk" That Reactivates Cancer Cells: When cancer cells receive signals to "wake up," Ephrin-B1 moves to the cell surface and interacts with EPHA2 on the same cell. This creates a kind of self-communication, where the cell activates its own signaling system. In this case, the signal flows in an unusual direction from the receptor to the ligand triggering what scientists call "reverse signaling." them to CSCs. Interestingly: The usual ("forward") signaling helps slow down tumor growth. But this reverse signaling has the opposite effect it promotes the awakening of dormant cancer cells and helps turn them into cancer stem cells.

Why This Matters: Our findings reveal a new way that cancer cells can activate themselves and become more aggressive. While this study focused on oral cancer, similar mechanisms may exist in other types of cancer and even in normal stem cell systems. From a treatment perspective, this discovery is important because cancer stem cells are often responsible for tumor relapse and resistance to therapy. We found that the unusual interaction between EPHA2 and Ephrin-B1 may disrupt normal cellular balance and contribute to these problems. This opens up the possibility of developing new treatments that specifically block this interaction.

Looking Ahead: We are now working on designing drugs that can prevent this unusual protein interaction. By blocking this "self-talk," we hope to stop dormant cancer cells from waking up and becoming dangerous again. With further research, this approach could lead to new strategies to prevent cancer recurrence and improve long-term treatment outcomes.

Dr. Maliekal's contributions are reflected in his publication in *Cell Communication Signal* (2026) 10.1186/s12964-026-02788-1



| EXPERT OPINION |

WHEN MAGNETISM AND VIBRATION WORK TOGETHER

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| Scientific Profile | | Organization Link | | Research Lab Page | | Factors Press |

Areas of Expertise: Magnetization Dynamics | Spintronics | Magnonics | Nanomagnetism

It is astonishing to see how sound and magnetism, two apparently unrelated phenomena, could interact in a significant way. One belongs to the world of vibrations and waves in matter, while the other governs the invisible forces behind magnets and electronic devices. Yet, when these two meet at the nanoscale, they give rise to a fascinating field known as magnetoacoustics, where vibrations can control magnetism and vice versa. This interplay is not just scientifically intriguing; it is opening doors to next-generation technologies in communication, sensing, and even quantum computing.

The Language of Waves: Magnons and Phonons: To understand this interaction, we must first introduce two key players: a) Magnons: These are collective excitations of spins in a magnetic material, essentially waves of magnetization. b) Phonons: These represent vibrations of atoms in a lattice, what we perceive macroscopically as sound or mechanical waves.

In magnetostrictive materials, i.e. materials that change shape under magnetic fields or change magnetization under strain, these two excitations can couple. This interaction is called magnon–phonon coupling, and it forms the foundation of magnetoacoustics. When a vibrating wave (phonon) travels through such a material, it produces strain. This strain alters the magnetic state, generating spin waves (magnons). Conversely, magnetization dynamics can generate mechanical vibrations. This two-way interaction is the essence of magnetoelasticity.

> *"When sound and magnetism meet at the nanoscale, they create a new language of energy where vibrations can control magnetism and unlock powerful technologies."*

When Coupling Becomes Strong: A New Hybrid World: In recent work by Anjan Barman and collaborators, an extraordinary phenomenon was observed: when magnons and phonons interact strongly, they no longer behave as separate entities. Instead, they hybridize to form a new quasi-particle known as a magnon-polaron. In a two-dimensional array of nanomagnets placed on a piezoelectric substrate, surface acoustic waves (SAWs) were used to excite vibrations. These vibrations interacted with spin waves in the nanomagnets. When their frequencies and wavevectors matched, a condition called phase matching, a strong coupling emerged, leading to nearly complete energy transfer between modes.

Even more remarkably, the study demonstrated tripartite coupling, where two magnon modes interact via an intermediate phonon mode (SAW). This resulted in the formation of a binary magnon-polaron, showcasing how rich and tunable these hybrid systems can be. This is not just a scientific curiosity. Strong coupling regimes allow coherent energy exchange (quantum transduction), a critical requirement for quantum technologies.

From Vibrations to Wireless Signals: Nanoantennas: What happens if this interacti-

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on can be extended further? Can vibrations and magnetism generate electromagnetic waves? The answer is yes, and this leads to one of the most exciting applications: magnetoelastic nanoantennas. In another groundbreaking study, Barman and co-workers demonstrated that phonons (acoustic waves) can excite magnons, which in turn emit photons, real electromagnetic radiation. This creates a chain of interaction: Phonons → Magnons → Photons

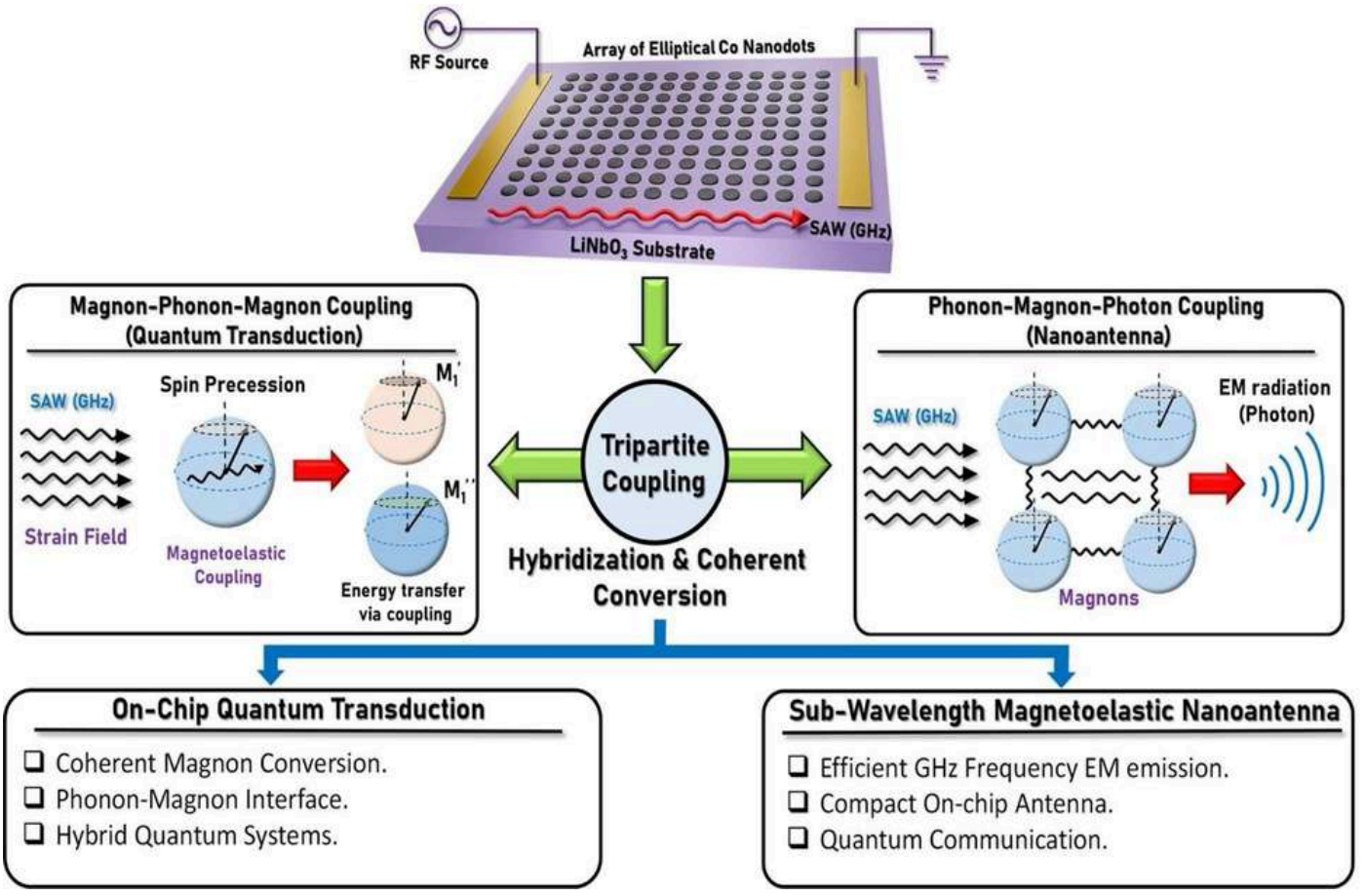
This tripartite phonon-magnon-photon coupling enables the creation of extremely small antennas, much smaller than the wavelength of the emitted radiation, yet with surprisingly high efficiency. Traditional antennas become inefficient when miniaturized, but these magnetoelastic nanoantennas overcome that limitation. Experiments showed that such antennas can operate in the GHz frequency range with efficiencies exceeding classical limits by orders of magnitude. Imagine wireless communication devices that are not only smaller but also more energy-efficient. This could possibly revolutionize everything from IoT devices to biomedical implants.

Implications for Quantum Technologies: The ability to coherently couple magnons and phonons, and even photons, has significant implications for quantum information science. Quantum computing relies on coherent control of quantum states. Hybrid systems like magnon-phonon platforms offer unique advantages:

i) Long coherence times (phonons are less prone to loss).
ii) Tunability via magnetic fields.
iii) Interfacing different quantum systems (spin, mechanical, electromagnetic).

Magnons can act as intermediaries between microwave photons and other quantum excitations, making them ideal for quantum transducers, devices that convert signals between different quantum platforms. The strong coupling observed in magnetoelastic systems provides a pathway for transferring quantum information between different carriers, a key requirement for scalable quantum networks.

A Broader Perspective: Engineering Hybrid Matter: What makes magnetoacoustics particularly exciting is its versatility. By precise engineering of nanostructures, such as arrays of nanomagnets on piezoelectric substrates, we



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can design systems where: frequencies are tunable via magnetic fields, coupling strength can be controlled geometrically and directional properties (anisotropy) can be exploited. These systems behave like artificial crystals, where waves interact in controlled and predictable ways. They allow us to explore new physical regimes and develop devices that were previously unimaginable.

Looking ahead, the convergence of magnetism and vibration is more than an interdisciplinary curiosity, it represents a new paradigm in controlling energy and information at the nanoscale. From hybrid quasi-particles like magnon-polarons to ultra-efficient nanoantennas and quantum transducers, magnetoelastic systems are redefining how we think about communication and computation. As research progresses, we may soon see practical devices where sound waves control magnetic memory, or where tiny antennas powered by vibrations enable seamless wireless connectivity in the smallest of devices. In the end, when magnetism and vibration work together, they do not merely coexist. They create entirely new possibilities.

Dr. Barman's contributions to this field are reflected in his publication in Nanoscale, https://doi.org/10.1039/D5NR04628A, NPG Asia Materials (2026), https://doi.org/10.1038/s41427-023-00499-4 and Advanced Science, https://doi.org/10.1002/advs.202104644

| EXPERT OPINION |

HYDROGELS: A NOVEL CLASS OF QUASI-SOLID ELECTROLYTES FOR SUSTAINABLE ENERGY STORAGE

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Areas of Expertise: Polymer Hydrogels | Quasi-solid Electrolytes | Electrochemical Supercapacitors | Fuel Cells

The global shift toward renewable energy is no longer a distant ambition but an unfolding reality. Solar panels and wind turbines a-re rapidly transforming how we generate power, yet they bring with them a persistent and consequential challenge: intermittency. The sun does not always shine, and the wind does not always blow. Bridging this gap requires efficient, safe, and genuinely sustainable energy storage systems. While much attention has been directed at improving energy storage devices such as batteries and supercapacitors, the real transformation may lie in rethinking the materials that make them work. Conventional energy storage technologies, particularly lithium-ion batteries, have powered everything from smartphones to electric vehicles. However, their environmental and ethical footprints are difficult to ignore. These systems depend on scarce and geopolitically sensitive elements such as lithium, cobalt, and nickel, whose extractions are energy-intensive, often linked to ecological degradation, and in some regions entangled with serious human rights concerns. Improper disposal further introduces toxic materials into soil and water systems. As a result, the search for greener and safer alternatives has become a central theme in modern materials science. A truly sustainable energy storage material must go beyond performance metrics such as energy density and cycle life. It should be abundant, non-toxic, recyclable, and ideally derived from renewable resources. This broader and more demanding perspective has directed researchers toward bio-derived materials, alternative chemistries, and safer electrolytes. Among these, hydrogel-based electrolytes are emerging as a particularly compelling solution.

> *"Hydrogels are not just materials, they are programmable three-dimensional architectures, capable of being engineered from the molecular scale upward to meet the demands of a green energy future."*

Hydrogels are, at first glance, deceptively simple: soft, water-rich materials that resemble a sponge. At the molecular level, however, they are sophisticated three-dimensional networks of hydrophilic polymers capable of retaining large quantities of water while maintaining structural integrity. This unique combination of softness and stability imparts hydrogels with remarkable versatility and they are already widely deployed across an impressive breadth of applications. In medicine, they are used for drug delivery, tissue engineering, and wound dressing, while in diagnostics they enable sensitive biosensing. They also serve as water-retaining materials in agriculture and as adsorbents for pollutant removal in environmental applications. Beyond this, hydrogels are increasingly explored in soft robotics and wearable electronics due to their responsiveness, biocompatibility, and mechanical flexibility. Hydrogels are formed by covalent and ionic crosslinking of polymer chains, creating a three-dimensional architecture that traps water within its matrix. Covalent bonds ensure structural stability, while ionic and non-covalent interactions contribute flexibility, self-healing behaviour, and the ability to adhere to surfaces.

In every electrochemical energy device, wheth-

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er a battery, a supercapacitor, or a fuel cell, the electrolyte occupies a central and often underappreciated role. It is the medium through which ions travel between electrodes. Its properties govern the device's operating voltage window, ionic conductivity, interfacial stability, safety, and long-term durability. For decades, this critical component has been dominated by liquid systems: aqueous solutions, organic solutions, and ionic liquids. While effective, these conventional electrolytes carry several serious liabilities. Organic electrolytes are flammable and toxic; ionic liquids are expensive; aqueous systems have low voltage window. This necessitates safer and affordable alternatives.

Hydrogels offer a compelling resolution to the limitations of conventional electrolytes. In the context of energy storage, they combine the best features of liquid and solid systems. Like liquids, they enable efficient ion transport through their water-rich interconnected pore networks. Like solids, they provide mechanical stability, eliminate leakage, and enable compact as well as flexible device architectures. Hydrogel electrolytes can be synthesized and operated under ambient conditions, making them cost-effective and user-friendly.

A wide range of biopolymers are available for hydrogel electrolyte design. Cellulose offers excellent mechanical strength and stability, while chitosan provides a positively charged network that supports efficient ionic conductivity. Alginate and gelatin contribute flexibility and strong film-forming ability. Other abundant materials such as guar gum and carrageenan further expand the scope for sustainable electrolyte development. What makes these materials scientifically powerful is the diversity of crosslinking strategies available. Covalent crosslinking, using agents namely glutaraldehyde and glyoxal, produces dense mechanically robust networks but may involve toxic reagents and can restrict ion mobility. Ionic crosslinking, by contrast, relies on electrostatic interactions between charged polymer groups and counterions from a salt or crosslinker. This approach is simpler, greener, and often preserves or enhances ionic conductivity, since the crosslinker ions themselves become mobile charge carriers within the hydrogel.

> *"Hydrogels are not just materials, they are programmable three-dimensional architectures, capable of being engineered from the molecular scale upward to meet the demands of a green energy future."*

Several hydrogel electrolytes have exhibited outstanding performance in electric double layer capacitors. A hybrid aqueous electrolyte system prepared using sulfuric acid and sodium sulfate with tungsten oxide electrodes demonstrated an exceptional cycle life of 250,000 cycles, representing one of the most durable systems. Similarly, chemically cross-linked polyacrylamide organo-hydrogel-based system achieved a long cycle stability of 100,000 cycles, while azepanium-based ionic liquid systems paired with activated carbon delivered 55,000 cycles. In our recent research, a series of biopolymer-based hydrogel electrolytes demonstrated progressively improved performance. The chitosan-sodium thiosulfate system exhibited the highest reported cycle life of 1,58,924 cycles, along with a high areal capacitance of 505.5 mF cm-2. This was followed by the gelatin-Al3+ system, which delivered 83,000 cycles. These results clearly demonstrated that systematic tuning of biopolymer chemistry and ionic crosslinking could lead to significant improvements in both electrochemical performance and long-term durability.

The hydrogel, shown in the inverted beaker, was synthesized by covalent crosslinking of gelatin with glutaraldehyde and subsequently processed into a flexible electrolyte film. Activated carbon powder was also derived from the same hydrogel through a carbonisation process. This was followed by integration with carbon-based electrodes to assemble an electric double layer capacitor. The fabricated cells were then connected in series to demonstrate practical applicability, successfully powering a red LED. This representation illustrates simple fabrication

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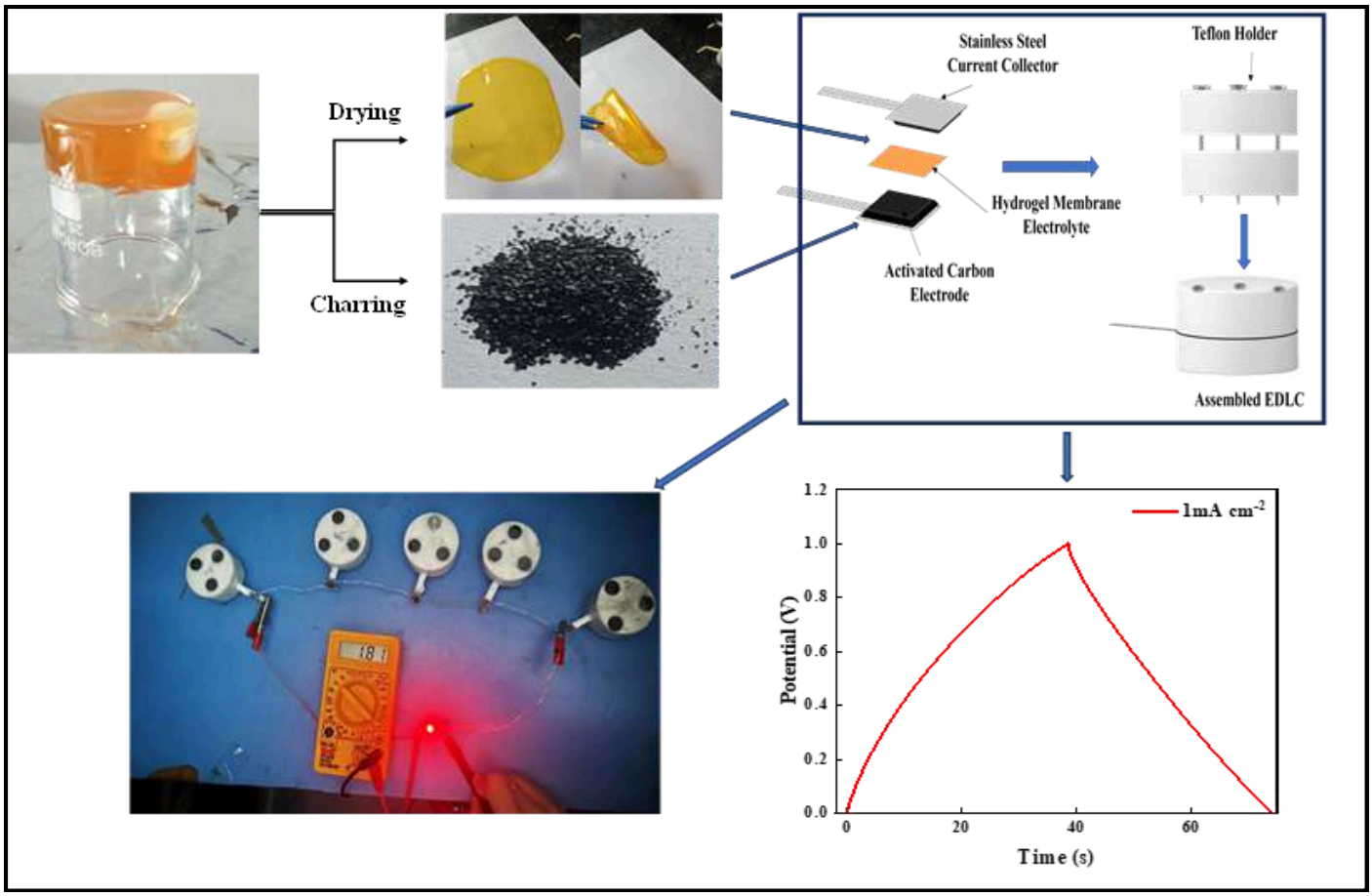
and ability of the hydrogel electrolytes to deliver usable electrical output for real-world applications.

Despite the significant advancements outlined here, serious challenges remain on the path from laboratory discovery to practical deployment. The electrochemical stability window of hydrogel electrolytes typically limited to low value. Strategies to widen this window include the use of water-in-salt electrolytes at high salt concentrations. Self-healing hydrogels, which automatically repair mechanical damage, represent another exciting frontier, offering the prospect of dramatically extended device lifetimes. Large-scale production of hydrogel membrane electrolytes is another challenge that can be addressed through innovative engineering. Finally, integrating hydrogel electrolytes with advanced electrodes offers promising near-term performance breakthroughs.

Dr. Choudhury's contributions to this field are reflected in his publication in *International Journal of Biological Macromolecules*.
https://doi.org/10.1016/j.ijbiomac.2026.150864

For early-career researchers interested in the intersection of polymer chemistry, materials science, and electrochemical engineering, this field presents an exceptional opportunity. The challenges are significant, and materials developed today will shape future energy storage. Moreover, the barriers to entry are lower than commonly assumed. Biopolymers are inexpensive and widely available, while straightforward fabrication approaches make experimentation accessible even in modest laboratory settings. As the discipline advances, there is a growing recognition that achieving high-performance energy storage must go hand in hand with sustainability. The next generation of researchers will play a crucial role in advancing this balance, contributing to technologies that are both efficient and sustainable.



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DUAL-TARGETING TUBULIN INHIBITORS: DEVELOPMENT OF AFFORDABLE CANCER THERAPEUTICS

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| Scientific Profile | | Organization Link | | Research Lab Page | | *Factors Press* |

Areas of Expertise: Medicinal Chemistry | Bioorganic Chemistry | Targeted Cancer Drug Design | Biocatalysis and Biotransformations

Cancer remains a major challenge for healthcare systems worldwide, but in India, where its prevalence is increasing and financial resources are limited, the burden is especially heavy. Despite significant advances in oncology, disparities in access to long-term, effective treatment persist, and many patients cannot complete therapy due to financial constraints. In this context, the search for innovative yet affordable therapeutic options are not only a scientific goal but also a social necessity.

As they can interfere with microtubule dynamics and prevent cell proliferation, tubulin polymerization inhibitors have long been a key component of anticancer therapy. The effectiveness of this class is shown by agents like vincristine and paclitaxel. However, issues such as medication resistance, dose-limiting toxicities, and challenges with pharmacokinetics and tissue selectivity often limit their usefulness. These limitations emphasize the need for next-generation strategies that can boost effectiveness while minimizing side effects.

In this context, dual-targeting strategies have emerged as a promising solution to these challenges. By inhibiting two critical molecular targets or pathways simultaneously, these agents can block compensatory mechanisms, enhance therapeutic synergy, and reduce the likelihood of resistance, while enabling dose reduction to minimize toxicity. Tubulin, a validated anti-cancer target regulating microtubule dynamics, is functionally interconnected with several key cancer-related pathways, including HDACs, angiokinases (e.g., VEGFR), topoisomerases, and PI3K/AKT/mTOR. Dual inhibition of tubulin and such pathways has demonstrated superior anti-tumor efficacy, anti-angiogenic activity, and reduced systemic toxicity in preclinical studies. Importantly, hybrid inhibitors can be purposefully designed to increase their selectivity for tumor cells, protecting healthy tissues and improving tolerability.

> *"The future of cancer treatment lies in smarter medicines single molecules that target multiple pathways, making therapy more effective, affordable, and accessible."*

Beyond their pharmacological benefits, dual-targeting inhibitors are also promising in addressing one of the most significant issues in oncology: cost. To achieve optimal results in many clinical cases, combination therapy involving multiple medications is often necessary, which can increase costs and complicate logistics. By integrating therapeutic properties into a single medication, a well-designed hybrid molecule can reduce treatment expenses, simplify regimens, and improve patient compliance. In resource-limited settings, this shift from multi-drug combinations to multifunctional single drugs may be especially advantageous.

The main goal in such research programs is to identify and develop tubulin-based dual-targeting inhibitors that can simultaneously influence multiple cancer-related pathways. This initiative aims to create innovative hybrid compounds with improved effectiveness and

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reduced toxicity by combining advanced computational techniques, such as pharmacophore modeling and AI-assisted screening, with rational drug design. Importantly, the approach extends beyond potency to focus on affordability, emphasizing the development of medicines that can be produced at a reasonable cost and become accessible treatment options. These efforts are part of a broader movement toward rational polypharmacology, where carefully designed single compounds could minimize therapy burdens while tackling the complexities of cancer. It marks a significant step toward developing next-generation, patient-centric cancer treatments suitable for resource-limited settings by bridging basic research with translational goals.

In the future, consistent interdisciplinary collaboration will be essential for successfully transitioning hybrid inhibitors from laboratory research to clinical application. Advances in rational drug design supported by machine learning and artificial intelligence will enable quicker identification of the most promising molecular candidates. To ensure cost-effectiveness and scalability, parallel progress in manufacturing techniques and drug delivery systems will be vital. It is achievable to develop treatments that are both cutting-edge and widely accessible by aligning scientific progress with clinical needs and societal priorities.

Dr. Kamal's contributions to this field are reflected in his publication in Expert Opinion on Investigational Drugs (2026), https://doi.org/10.1080/13543784.2026.2640986

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THE STORY BEHIND HOW A COMMON ACIDITY DRUG PROTECTS A VITAL BLOOD PROTEIN FROM ANTIBIOTIC STRESS

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| Scientific Profile | | Organization Link | | Research Lab Page | | Factors Press |

Areas of Expertise: Drug–Protein Interactions | Protein Misfolding & Aggregation | Biophysical & Computational Analysis | Drug Discovery

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Areas of Expertise: Drug–Protein Interactions | Protein Misfolding & Aggregation | Biophysical & Computational Analysis | Drug Discovery

It began not with a sweeping hypothesis, but with a focused question. During her MSc dissertation, Miss Sakhaviya was examining how commonly used antibiotics influence the structure and ligand-binding function of human serum albumin, the principal protein responsible for transporting drugs in the bloodstream. The work was grounded in a precise objective: to understand how structural perturbations in this protein might alter its ability to bind and carry molecules. As the results started to take shape, our discussions repeatedly returned to a simple clinical reality. These antibiotics are rarely prescribed in isolation. In routine practice, they are often administered alongside medications for acidity, particularly proton pump inhibitors such as pantoprazole. That observation gradually shifted the direction of the study. Instead of focusing on a single drug–protein interaction, the question evolved into something more representative of real-world conditions: what happens when multiple drugs interact simultaneously with the same protein?

> "Drugs rarely act alone within the body, they meet on shared proteins, where subtle interactions can reshape their behavior and impact."

To approach this, it became necessary to consider the structural sensitivity of human serum albumin itself. Its function depends on a finely maintained three-dimensional conformation, and even subtle disturbances can influence how it binds drugs, how long those drugs remain in circulation, and how effectively they reach their targets. If one drug alters this structure, the implications extend beyond its own transport, potentially affecting the behavior of others present in the system. Within this context, we began to ask whether pantoprazole, beyond its primary role in reducing gastric acidity, could influence the protein against such disturbances.

What emerged from the data was not an obvious interaction, but a consistent one. Ceftriaxone induced structural perturbations associated with unstability a-

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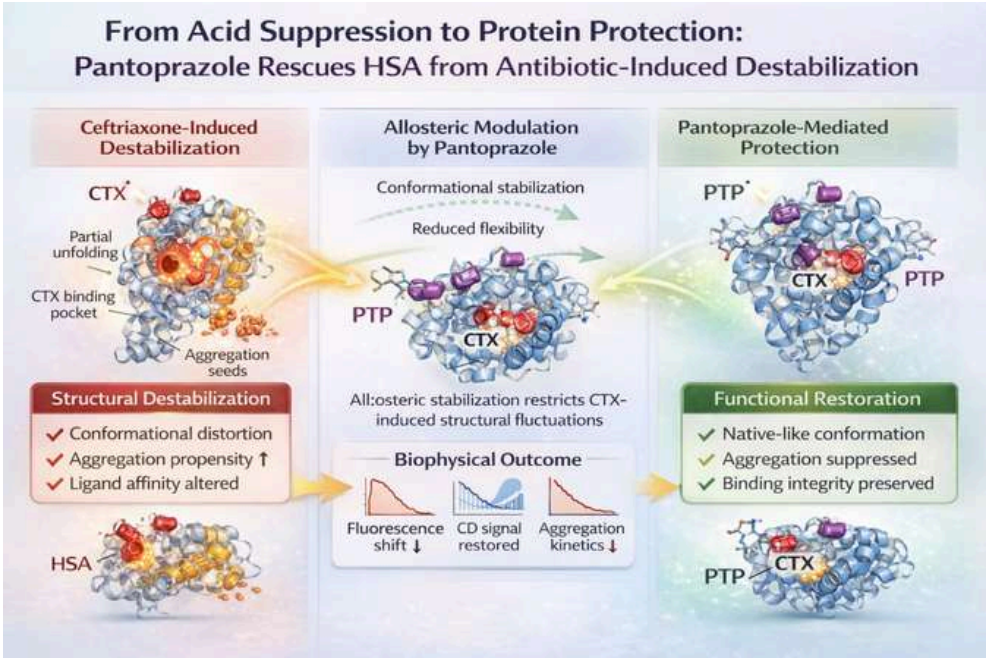
nd aggregation. In contrast, pantoprazole appeared to counterbalance these effects, restoring features of the protein's native conformation. The two drugs did not compete for the same binding site, suggesting that the effect was not driven by direct displacement. Instead, the observations pointed toward an allosteric mode of stabilization, where binding at one region of the protein subtly influences its overall structural landscape. The strength of this finding lay in its reproducibility across different approaches. Spectroscopic analyses indicated preservation of structural elements characteristic of native albumin. Aggregation studies showed a clear reduction in self-association under conditions where destabilization would otherwise be expected. Computational modeling supported these observations, suggesting interactions consistent with a stabilizing influence at the molecular level. Each method offered a different perspective, yet all converged on the same conclusion.

What was particularly striking was not only the presence of this effect, but its consistency. Pantoprazole is generally regarded as a supportive medication, prescribed to manage acidity rather than to influence protein behavior. Yet in this setting, it appeared to play a more active role, contributing to the maintenance of protein stability in the presence of a destabilizing agent. The observation does not redefine its primary function, but it does explain and how its role can be understood at the molecular level. This brings attention to a broader point. Drug combinations are typically evaluated in terms of clinical outcomes, but their molecular interplay often remains insufficiently explored. Proteins such as human serum albumin act as shared platforms where multiple drugs converge. Interactions occurring at this level need not be competitive to be meaningful. Changes in protein conformation can indirectly influence how different molecules bind, dissociate, or redistribute within the system.

Such effects are unlikely to be immediately visible in standard clinical settings. They do not necessarily produce overt signals, yet they can shape the biochemical environment in subtle ways. The findings here suggest that co-administered drugs may influence each other indirectly through shared biological targets, modifying protein structure and, in turn, affecting drug behavior. The work does not attempt to generalize beyond its scope, but it does point toward an additional layer of interaction that deserves closer attention. Understanding how drugs collectively influence protein stability could provide deeper insight into variability in therapeutic response and open new directions for studying combination treatments.



> "Sometimes, a supporting drug does more than assist, it quietly stabilizes the system, revealing hidden layers of molecular interplay."

Dr. Ahmad's contributions to this field are reflected in his publication in *Spectrochimica Acta A Molecular Biomolecular Spectroscopy* (2026). 10.1016/j.saa.2026.127661

| EXPERT OPINION |

CHEMICALLY DIRECTED BIOLOGY AND COURSE CORRECTION IN EVOLUTION

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| Scientific Profile | | Organization Link | | Research Lab Page | | Factors Press |

Areas of Expertise: Chemical Biology | CRISPR, Genome Engineering | PROTAC | Synthetic Biology

Humans are nothing but spatiotemporally regulated bags of molecules. Some are small molecules, some are large. These trillions of tiny bags can survive, often proliferate, and communicate using such different molecules. The spatiotemporal regulation of molecules inside the bags is the key to our survival and evolution. The regulation is, though, primarily controlled by the inheritable instructions stored in the form of genetic material. Mobility, motor function, and emotion are the outcomes of molecular interplay at the cellular and intercellular levels, controlled by genetics and its dynamic expression epigenetics. While nature has evolved cells into near-perfect machines for various functions, including self-replication, the embedded infinitesimal imperfection plays a key role in the evolutionary trajectory. The tiny change in genomic composition, whether through vertical or horizontal gene transfer, creates a new molecular game that often becomes a gamble for the cells. The change can benefit cells or even cause a disaster at both the cellular and the organismal levels. Genetic diseases are examples of such genetic misadventures that occur naturally during evolution. Although molecular dysregulation, compounded by environmental influences, drives human disease and suffering, it has also inspired the development of sophisticated molecular interventions aimed at restoring biological function, even sometimes enhancing performance. Molecular interventions include small-molecule drugs, nucleic acids, antibodies and antibody-drug conjugates. Small molecules remain the majority (~80–90%) of molecular therapeutics due to their ease of development, low cost, stability, and cell permeability. Small molecules can perform a range of functions, including binding and/or inhibiting biomolecules, activating biomolecules, stabilizing or degrading biomolecules, and compartmentalizing biomolecules to achieve therapeutic outcomes. Our lab focuses on developing small-molecule agents that can engage specific proteins of interest and degrade them using the cell's own shredding machinery, the proteasome, popularly known as PROTACs (Proteolysis-Targeting Chimeras).

> *"We develop bifunctional molecules and CRISPR-tracking strategies to degrade harmful biomolecules and safely correct genes, positioning small molecules as a missing link in the central dogma."*

We target proteins known to transform normal cells into a disease state, including cancer. Our developed bifunctional molecules can drag the harmful protein to the proteasome and enforce degradation. By degrading disease-causing proteins, one can rescue cell function and develop a therapeutic modality. Our group leveraged the potential of the PROTAC strategy and diversified the toolkit to broaden its application. For example, instead of directly engaging the target proteins, we developed molecules that can target non-protein biomolecules and degrade the interactomes of their interacting proteins. In this way, we developed a PROTAC molecule that can engage telomeric G-quadruplex DNA and target telomere-maintaining proteins, such as telomerase, which are known to be involved in tumorigenesis. Such a method enhances effica-

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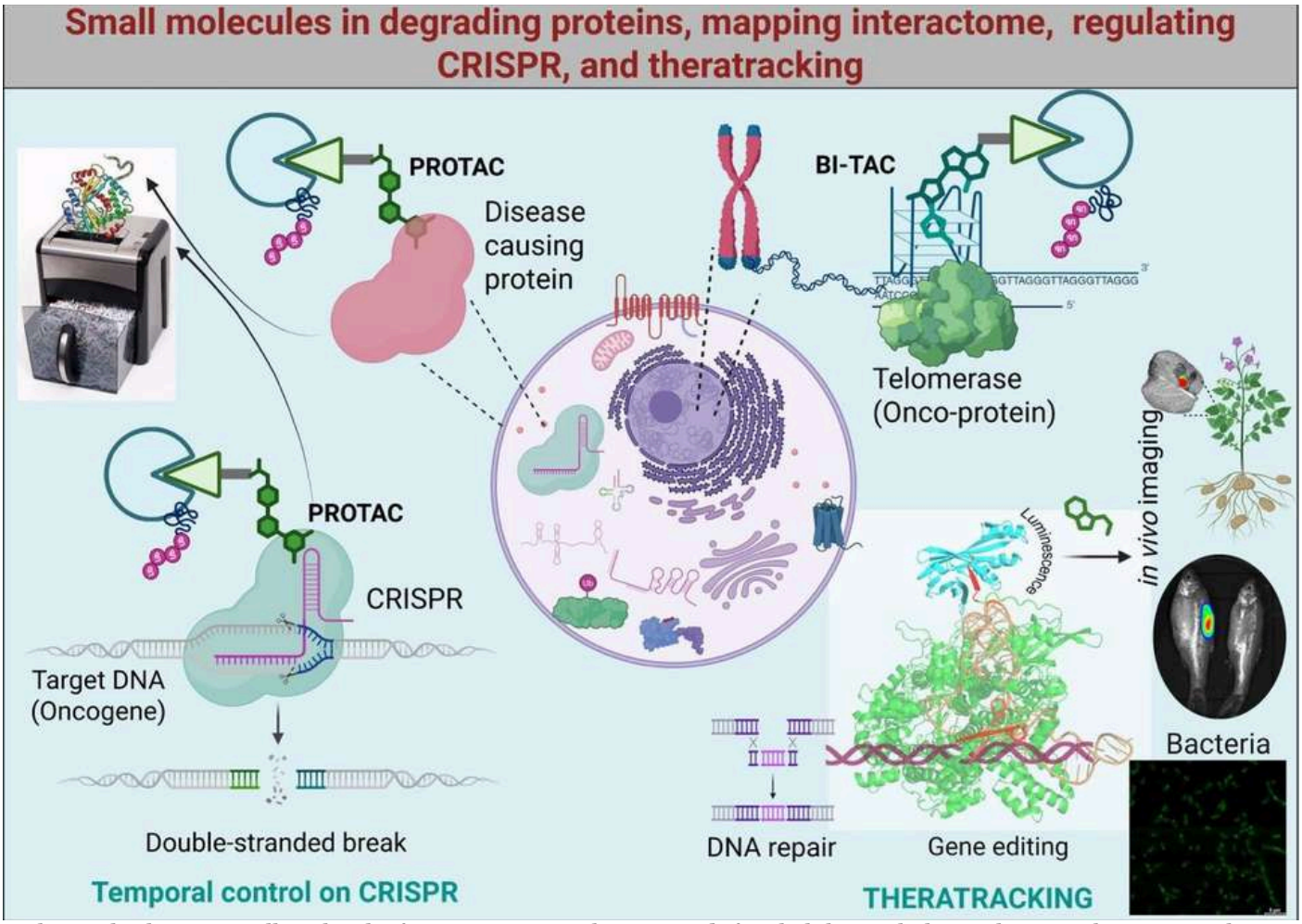

cy by multiplexing small-molecule functions, such as G-quadruplex DNA stabilization and telomerase inhibition, with telomerase protein degradation, leading to genomic instability and damage, followed by eventual programmed cell death. Our lab is developing various other PROTACs, which we call Biomolecular Interactome Targeting Chimera (BI-TAC), for targeting different biomolecules and their protein interactomes. Such PROTACs are rapidly advancing into clinical trials due to their specificity, catalytic activity, and ability to target undruggable proteins. However, certain diseases, especially hereditary genetic diseases, require more advanced therapeutic intervention for a permanent cure. Gene therapy represents a transformative approach for correcting pathogenic mutations and treating a wide range of rare genetic diseases. Some of the deadly genetic diseases include muscular dystrophies, Sickle Cell Anemia, Cystic Fibrosis, and familial hypercholesterolemia, where gene therapy appears to have the potential to achieve durable or curative outcomes. CRISPR-based genome engineering is the most advanced and effective technique for correcting defective genes. Numerous CRISPR-based gene therapy methods have been developed to address a number of genetic diseases, and many of them are in clinical trials. CRISPR has also been employed in controversial germline editing experiments aimed at introducing mutations in human embryos to confer permanent resistance to HIV; however, it raised significant ethical and regulatory concerns. Apart from unethical germline editing, off-target-mediated genotoxicity remained a serious concern in gene therapy. Spatiotemporal regulation of CRISPR activity provides an additional layer of safety, enabling more precise, controllable, and context-dependent gene therapy applications. We employ a PROTAC strategy to achieve temporally regulated CRISPR systems with improved specificity. A different kind of bifunctional small molecule has been developed that specifically binds to the CRISPR enzyme Cas9 and degrades it, turning it off. Temporal control of CRISPR activity mitigates off-target effects, thereby enhancing the precision and safety of CRISPR-based genome engineering. While one can improve target gene specificity by controlling off-target activity, tissue-specific activity is a major concern

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in gene therapy. In most cases, the target gene sequence is ubiquitously present across all cells in our body. Thus, a gene therapy trying to activate the tumor suppressor protein p53 in cancer tissue may also target other healthy organs and cause serious side effects. Given this, tissue-specific gene editing is crucial for achieving the intended genomic alteration or cure without causing on-target toxicity in off-target tissues or organs. While theranostics is a well-established strategy for the simultaneous diagnosis and treatment of diseases, we introduce a "theratracking" strategy for real-time monitoring of gene therapy. We developed methods for detecting the CRISPR-associated enzyme Cas9 using either a fluorogenic small molecule or a combination of protein engineering and a small molecule. For example, we developed a fluorogenic small-molecule RhoNiN that selectively binds the Cas9 enzyme via a short peptide—6X-His tag. Much like the NiNTA-based His-tag protein purification method, the fluorogenic small molecule can bind to His-tagged Cas9 to detect and probe Cas9 in real time. In a more advanced strategy, we developed an engineered thermostable Cas9 system GlowCas9 that emits bioluminescent light in the presence of a small-molecule substrate while performing gene editing. The CRISPR-associated enzyme Cas9 was genetically engineered to incorporate sticky ends derived from the deep-sea shrimp bioluminescent enzyme Nanoluciferase. While the nanoluciferase-derived sticky ends help Cas9 fold more efficiently and make it thermostable, they also generate luminescent light when in contact with a small-molecule substrate. GlowCas9 obviates the need for costly antibody-based detection of Cas9 across diverse experimental formats, including both in vitro and in vivo systems. In addition to its tracking ability, the CRISPR reporter system can efficiently disrupt target genes or repair malfunctioning genes to restore proper function in human cells. This approach enables real-time tracking of CRISPR activity and its spatial distribution within an organism, allowing timely intervention to enhance on-tar-get specificity and improve the safety of gene therapy. Among interventions, chemical inhibitors that can block CRISPR activity and safeguard genetic materials from unintended alteration or disruption are of high priority. Our future efforts will be directed toward harnessing microbes as microreactors to develop such chemical inhibitors, thereby establishing a high-throughput, economically viable drug discovery platform.

Overall, while nature explores the future course of evolution through genetic and epigenetic adventures, often entering a detrimental "Death Valley" of genetics, our lab is developing chemical interventions to rescue from such evolutionary trajectory missteps. Our lab envisions small-molecule chemical probes not as external players but as the "missing link in the central dogma".

Dr. Maji's contribution to the filed reflects in the publications in Nanoscale (2024) (DOI: 10.1039/D4NR01006J), Angewandte Chemie (2025) (DOI: 10.1002/anie.202511707).

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.

| By Dr. Avijit Das

THE SECRET LIFE OF CITY WATER

Ritika never imagined that the small drain behind her school could change the way she saw the world. Every afternoon in Bhubaneswar, she would walk past it without a second thought until one day her science teacher, Mr. Devansh Rao, paused beside it and said, "If you really want to understand a city, don't just look at its buildings. Look at its wastewater." That sentence stayed with her. A few weeks later, Ritika got the chance to visit a research lab as part of a school program. There she met Dr. Nandini Iyer, a microbiologist who studied microbes in wastewater. As Ritika looked at screens filled with colorful graphs and strange names, she asked, "How can dirty water be so important?"

Dr. Nandini smiled. "Because this water carries the story of an entire city. It contains bacteria from homes, hospitals, farms, industries, everything. Scientists recently studied wastewater from Delhi, Mumbai, Chennai, and Kolkata to understand a growing danger called antibiotic resistance." Dr. Nandini explained that antibiotics are medicines used to kill harmful bacteria, but many bacteria are learning how to survive them. This is called antimicrobial resistance, and it is becoming one of the biggest threats to human health. "Imagine a future where even a small infection cannot be treated," she said. "That's what we are trying to prevent." The scientists in the study collected hundreds of wastewater samples over two years from different parts of these cities. They used a powerful method to read all the DNA present in the water.

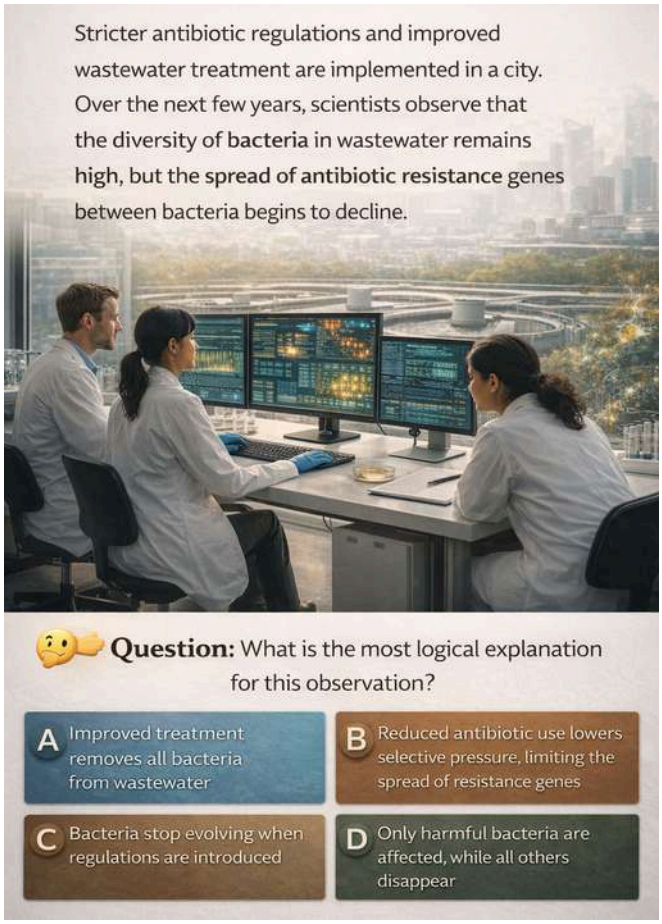
It was like opening a giant book written by thousands of invisible organisms. This helped them see not only which bacteria were present, but also what genes they carried, especially those that make them resistant to antibiotics. Ritika watched as Dr. Nandini showed her a map on the screen. Each city had a different pattern. "Why are they different?" she asked. "Because every city has its own environment, lifestyle, and habits," Dr. Nandini replied. "These shape the microbial communities. So the bacteria in Mumbai may not be the same as those in Kolkata." Ritika found it fascinating that each city had its own invisi-

| By Dr. Avijit Das

ble identity.

But then Dr. Nandini pointed to something more concerning. Among the bacteria found in the wastewater were some well-known troublemakers like Escherichia coli, Klebsiella, and Pseudomonas. These bacteria can cause infections and are often linked to antibiotic resistance. Then came the most surprising part. “When we tried to identify all the bacteria,” Dr. Nandini said, “we found that more than half of them didn’t match any known species. They could be completely new.” Ritika’s eyes widened.

As Ritika absorbed this, she asked another question. “So are these bacteria the same in every city?” “Not exactly,” Dr. Nandini replied. “The types of bacteria differ. But interestingly, the resistance genes they carry are quite similar.” “Why would that happen?” “Because people across cities use similar antibiotics,” she explained. “This creates similar pressure, forcing bacteria everywhere to develop similar resistance strategies.” But there was one final twist. Some of these resistance genes were found on special pieces of DNA that could move between bacteria. “Think of them as tiny vehicles,” Dr. Nandini said. “They carry resistance from one bacterium to another even across different species.” “So bacteria can share their defenses?” Ritika asked. “Yes,” she said. “And that’s what makes the problem more serious.” As the visit ended, Ritika stepped outside and noticed a drain flowing beside the road. It looked exactly like before but she saw it differently now. It was no longer just wastewater. It was a living system, full of unseen activity and hidden warnings. That evening, Ritika opened her notebook and wrote: “Every city has a secret life beneath its streets. In the flowing wastewater, there are stories of health, disease, survival, and change. If we learn to listen, we can understand the future before it arrives.” And from that day on, she never ignored a drain again.



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CSIR - Centre for Cellular & Molecular Biology, Hyderabad, Telangana, India and AcSIR- Academy of Scientific and Innovative Research (AcSIR), AcSIR Headquarters CSIR-HRDC Campus, Ghaziabad, Uttar Pradesh, India

| By Dr. Poulami Chakraborty

WHEN SUMMER FORGOT TO BURN

Aditi had grown up hearing the same sentence every year: "This summer will be worse than the last one." In her home in Nagpur, summer meant hot winds, burning roads, and afternoons so harsh that even the trees seemed tired. So when she joined her school's climate science club and heard a visiting scientist say, "More carbon dioxide can sometimes cool India in summer," she almost laughed. To her, that sounded impossible. Dr. Shashank Menon, the visiting climate scientist, stood in front of a map glowing red almost everywhere Europe, North America, and much of Asia. But over India, there was a pale blue patch. "This," he said, pointing to the blue, "is one of the most surprising things climate scientists have found. Even though CO_2 usually warms the Earth, it can also create a summer cooling effect over India."

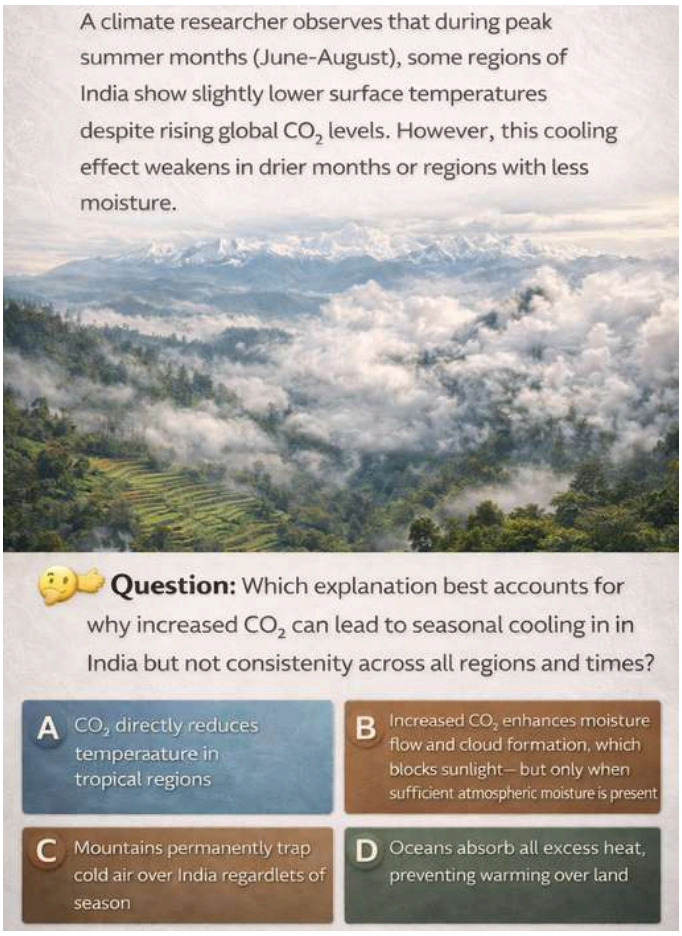
After the session, Aditi hurried after him. "Sir," she asked, "how can more CO_2 cool anything?" "It does warm the Earth overall," he replied. "But the climate is not simple. The atmosphere, land, oceans, mountains, and clouds are all connected. If one part changes, another part can react in an unexpected way." The next day, still curious, Aditi visited her cousin Rohan, who studied geography and loved explaining science with drawings. He opened a notebook and sketched India, the Arabian Sea, the Bay of Bengal, and the giant curve of the Himalayas. "Start here," he said. "When CO_2 increases, big land areas like Eurasia warm faster than nearby oceans. That makes the temperature difference between land and sea stronger."

"And then?" Aditi asked. "That stronger difference pulls more moist air from the surrounding oceans toward India, especially during summer," he said, drawing arrows toward the subcontinent. Aditi nodded. She understood monsoon winds. Every year, summer in India brought not just heat, but heavy, moisture-filled air. But Rohan continued. "Now imagine that moist air reaching India and crashing into the Himalayas and the Hindu Kush mountains. Those mountains act like giant walls. They force the air upward." "And rising air cools," Aditi said slowly, "which helps form clouds." "Exactly."

By Dr. Poulami Chakraborty

Now the story was beginning to make sense. More CO_2 warms the giant Eurasian landmass. That stronger warming pulls in more moist air toward India. The mountains force the moist air upward. More rising air means more cloud formation. “And clouds block sunlight,” Aditi said. Rohan smiled. “That’s the key. Even though CO_2 traps heat in the atmosphere, the extra cloud cover acts like a giant umbrella. It blocks part of the Sun’s energy from reaching the ground. So the land surface can cool.” The next day, Aditi returned to Dr. Shashank with a new question. “Sir, is cloud cover the main reason for the cooling?” “Yes,” he said. “CO_2 does not directly cool India. Instead, it changes winds, moisture movement, and cloud formation. Those extra clouds reduce the amount of sunlight reaching the surface.”

He then showed her another graph. “There’s more. The winds also bring slightly cooler air from the Arabian Sea inland. That adds to the cooling too. So it’s not one single cause. It’s a combination of moisture, rising air, mountains, cloud cover, and cooler winds.” Aditi stared at the graph. “Does this happen all year?” “No,” he said. “Mostly from June to August, the peak monsoon months. That is when the atmosphere has enough moisture for strong cloud development. In drier months, this effect becomes much weaker.” That evening, Aditi wrote in her notebook: Climate change is not simple. It is not just about rising temperatures everywhere. Sometimes the same CO_2 that warms the world can also change winds, clouds, and rainfall in ways that cool one region for a season. When summer returned, the heat was still real. But Aditi saw it differently now. She no longer thought of climate as a straight line from “more CO_2” to “more heat.” Instead, she saw it as a living system where land, ocean, mountains, and sky all talk to each other. And every time dark monsoon clouds gathered above India, she remembered one surprising truth: Sometimes, in a warming world, summer forgets to burn.



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By Mrinal Kashyap

THE INVISIBLE CHEMICALS BENEATH THE GANGES

Ananya had always believed the Ganges was sacred not just in stories, but in reality. Growing up in Haridwar, she had seen people pray by its banks, drink its water, and trust it deeply. To her, the river was pure. One summer, she joined a student visit to a research lab at Indian Institute of Technology Roorkee. There, she met Dr. Vivek Sharma, an environmental scientist studying something she had never heard of PFAS. “Have you ever heard of ‘forever chemicals’?” he asked. Ananya shook her head. “These are chemicals used in products like non-stick pans, waterproof jackets, and industrial materials,” he explained. “The problem is, they don’t break down easily. Once they enter the environment, they stay for a very long time.” Ananya frowned. “Are they in the Ganges?” “That’s exactly what we wanted to find out,” he said.

The next day, Ananya joined the research team on a field trip. They collected samples along the river from Rishikesh to Haridwar and toward Roorkee. But instead of water, they dug into the riverbed. “Why sediments?” she asked. “Because sediments act like storage,” said Mehul. “Pollutants settle here and stay hidden for years. Even if the water looks clean, the real story is below.” Back in the lab, Ananya watched as the samples were prepared and tested. The scientists used advanced machines to detect chemicals she could barely pronounce. “We are looking for more than 40 types of PFAS,” Dr. Vivek explained. “But many are still unknown, so we use different methods to understand the full picture.”

Days later, results began to appear. “We found several PFAS in the sediments,” Mehul said. “Some were present in almost every sample.” “Is that bad?” she asked. “It means these chemicals are widespread,” he replied. “Especially the smaller ones, called short-chain PFAS. They move easily through water.” Ananya noticed one name repeating TFA. “That one was found in all samples,” Dr. Vivek said. “But the amounts look small,” she said. “Yes,” he nodded, “but they build up over time.” Then came a surprise. “This is the total fluorine in the sediments,” Dr. Vivek said. The number was much higher than expected.

By **Mrinal Kashyap**

"Where is the rest coming from?" Ananya asked. "That," he said quietly, "is the real concern." He explained that the known PFAS accounted for only a tiny fraction less than 2% of the total fluorine present. "So most of the chemicals are unknown?" she asked. "Yes. We call it the 'fluorine gap.' It means many hidden chemicals cannot be directly detected." To understand this better, the team used another method that converted hidden chemicals into detectable PFAS. After this, the numbers increased. "These are precursor compounds," Mehul explained. "They may not seem harmful now, but over time they can turn into toxic PFAS." Ananya felt uneasy. "So the river has chemicals we can't fully measure?" "That's right," Dr. Vivek said. "And that makes pollution harder to control."

As days passed, Ananya learned more. Some locations had higher contamination, especially near industrial areas. Even samples from the same place could differ. "Pollution doesn't spread evenly," Mehul said. "It depends on human activity and water flow." One evening, as the sun set over the Ganges, Ananya stood quietly by the riverbank. The water looked calm, reflecting the golden sky. It looked pure. But now she knew better. That night, she wrote: "The Ganges carries more than water. It carries stories of people, industries, and invisible chemicals we are only beginning to understand. What we see is only a small part." The research team later concluded that India needs stronger monitoring and better pollution control for PFAS. Without proper systems, these chemicals could continue to build up silently. They also emphasized the need for awareness among people, industries, and policymakers so that such hidden pollution can be reduced before it becomes an irreversible environmental and health crisis. For Ananya, the river would never look the same again. Not because she lost faith in it. But because she finally understood it.

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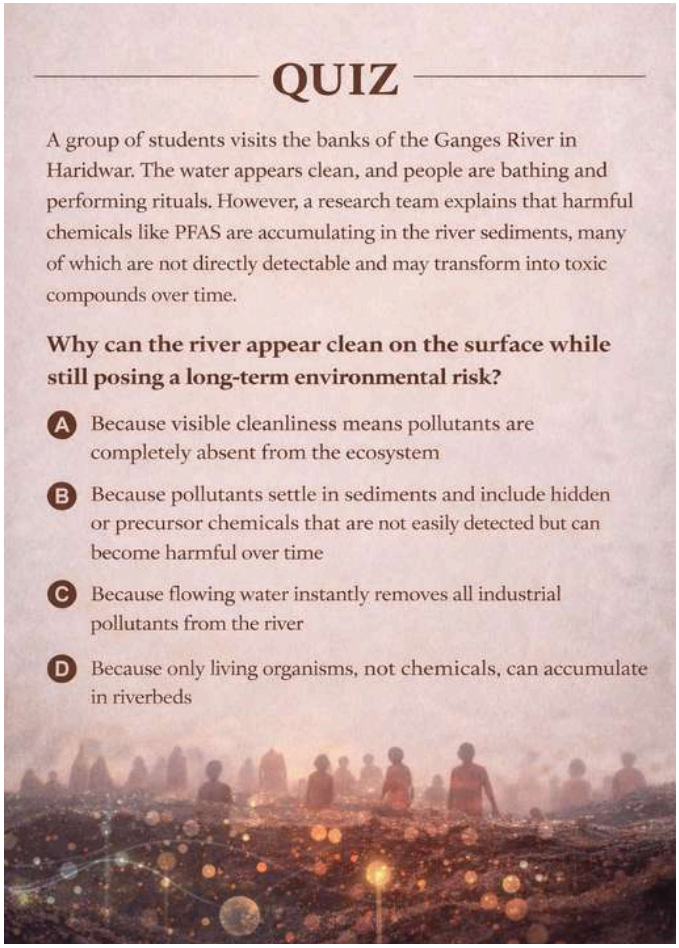


| By Dr. Sourav Kumar

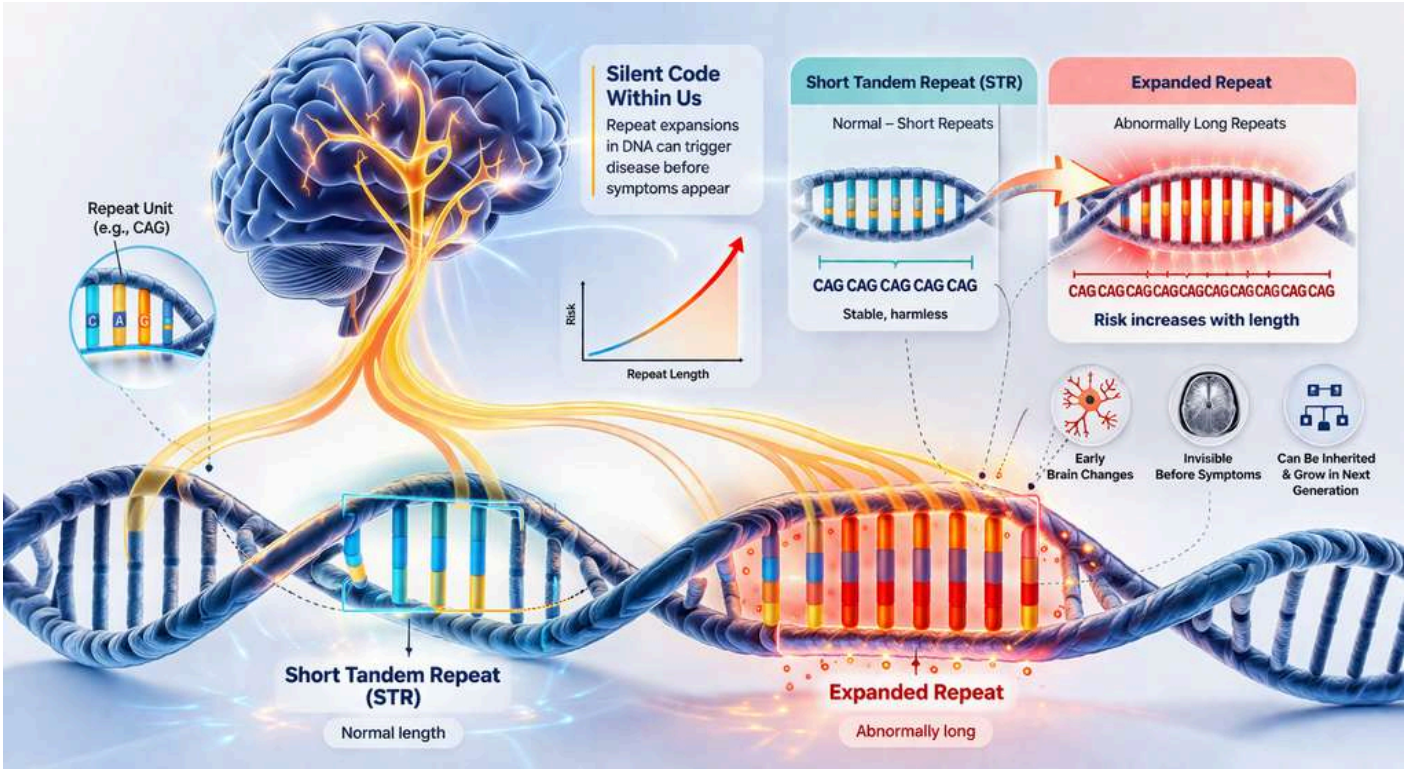
THE SILENT CODE WITHIN US

In a modern genetics lab in New York, Dr. Aarav Mehta spent his days studying patterns hidden deep inside human DNA. What looked like simple repeating letters to others felt like a secret language to him. His team Dr. Nisha Verma, a geneticist, Rohan Iyer, a data scientist, and Dr. Elena Costa, a neurologist shared the same curiosity. One day, Aarav gathered them and said, "We know that some brain diseases are caused by repeat expansions in DNA, but what if these changes are more common than we think?" The team decided to investigate a type of DNA pattern called short tandem repeats, or STRs—small sequences that repeat again and again. Normally, they are harmless, but when they grow too long, they can lead to serious diseases like Huntington's disease and muscle disorders.

To find answers, the team worked on a massive project. They collected genetic data from more than one million people across different populations. Using advanced sequencing tools, they examined repeat lengths in 37 important genes linked to diseases. Weeks turned into months as they analyzed the data. Then one evening, Rohan made an exciting discovery. "You need to see this," he said. On the screen, the data showed something unexpected: many more people carried these harmful repeat expansions than those actually diagnosed with disease. Elena looked surprised. "That means people can carry these risky changes without knowing it," she said. Aarav nodded. "Yes, and the disease may appear later in life."

As they explored further, the team noticed another important pattern. The risk of disease did not appear suddenly; it increased gradually with the length of the repeat. Nisha explained, "The longer the repeat, the higher the risk. It's like slowly turning up a volume knob." This idea changed how they understood genetic diseases. It was not just about having a mutation, but about how large that mutation had become.

Elena then brought in brain imaging results. "Look at these scans," she said. They showed that even people without symptoms already had changes inside their brains. Some brain regions were shrinking, and certain proteins in the blood, which indicate nerve damage, were higher than normal. Aarav was amazed. "So the disease starts long before symptoms appear?" he asked. Elena replied, "Yes, much earlier than we ever thought." This meant that the body was giving early warning signals, but they were invisible without advanced tools.



| By Dr. Sourav Kumar

The team also studied people from different parts of the world. They found that some populations had higher frequencies of certain repeat expansions. Rohan explained, “This helps us understand why some diseases are more common in certain regions.” It showed that ancestry and genetics together influence disease risk. Nisha added another important point: “These repeats can grow when passed from parent to child.” Aarav thought for a moment. “So a child could inherit a longer repeat and have a higher risk than the parent?” “Exactly,” she said. “That’s why some diseases appear earlier or more severely in the next generation.”

To make their study even stronger, the team connected genetic data with medical records. They examined thousands of diseases and traits, looking for patterns. Again and again, they found clear links between repeat length and disease risk. Aarav said during a meeting, “We are not just studying one disease. We are uncovering a hidden system inside the human genome.” The team realized that these repeat expansions act like silent signals, slowly building risk over time.

As their work came to an end, Aarav stood by the lab window, watching people walk by outside. Each person carried a unique genetic code, with patterns that could shape their future. He realized something deeply important: many diseases do not begin suddenly. They start quietly, developing over years, hidden in tiny repeating sequences of DNA. With this new understanding, scientists might one day detect diseases earlier, even before symptoms appear.

Turning back to his team, Aarav said, “This is not just about discovering disease. It’s about giving people a chance to act early.” Elena smiled. “If we can see the warning signs sooner, we may be able to slow or prevent these diseases.” The team knew their work was just the beginning. But they had uncovered something powerful the silent code within us, a hidden story written in our DNA.

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Regeneron Genetics Center, Tarrytown, NY, USA.

QUIZ

A 35-year-old individual undergoes a genetic test and is found to carry a moderately expanded short tandem repeat (STR) in a gene linked to a neurological disorder. However, they currently show no symptoms and are completely healthy. Brain imaging also shows very subtle changes that are not noticeable in daily life.

Question: Which explanation best describes this situation?

A. The person will never develop the disease because symptoms are absent at this age

B. The repeat expansion is harmless unless it reaches a fixed threshold, after which disease appears suddenly

C. The repeat length increases disease risk gradually, and early biological changes can occur long before visible symptoms

D. Only people with a family history of the disease can be affected by repeat expansions

| By Dr. Priyanka

STEPS THAT SHAPE A LIFETIME

In the sunny city of Brisbane, Emma Wilson had just turned fifty, balancing family, work, and daily responsibilities, with little time left for exercise. During a routine health check-up, her doctor told her something simple yet powerful: even small steps today can shape health in the future. Curious, Emma joined a long-term study along with thousands of Australian women. This study followed women for many years, collecting information about their physical activity and health. Leading the study were researchers like Dr. Sarah Thompson and data analyst Liam Carter, who wanted to understand how exercise during middle age affects the chances of living longer. The women in the study were mostly between 50 and 70 years old during the observation period, allowing scientists to carefully track health changes across important life stages.

Every three years, Emma reported how active she had been. Some years she walked regularly and joined fitness classes, while other years she became inactive due to life pressures. More than 11,000 women like her contributed to this study over about 15 years, creating a valuable dataset that reflected real-life changes in behavior over time. Since it was not possible to force people to exercise for such a long period, the researchers used a method called “target trial emulation,” where they used real-life data to imitate what would happen in a long-term experiment. This approach allowed them to compare different patterns of physical activity as if the women had been assigned to different groups in a controlled trial.

They grouped women based on their activity patterns: some consistently met the recommended 150 minutes of weekly moderate-to-vigorous physical activity, some never met it, and others started exercising later in life around ages 55, 60, or 65. Emma’s own habits changed over time, placing her in different groups. When Liam analyzed the data, a clear pattern appeared: women who remained consistently active had a much lower risk of dying compared to those who were inactive. In fact, regular physical activity reduced the overall risk of death by about half, which was one of the strongest findings of the study and supported global health recommendations.

| By Dr. Priyanka

However, when the researchers examined specific causes like heart disease and cancer, the results were less certain. There were signs that exercise helped, but the evidence was not strong enough to make firm conclusions, possibly because fewer cases were observed in these categories. They also studied whether starting exercise later in life could still help. The results suggested it might, but again the evidence was not very strong. This indicated that while starting late is better than not starting at all, the greatest benefit comes from staying active over many years. The researchers also carefully considered other factors like smoking, diet, stress, body weight, and health conditions, using advanced statistical methods to reduce bias and improve the accuracy of their findings. They even adjusted for factors that change over time, such as weight or health conditions, which can both influence and be influenced by physical activity.

Emma's life reflected these results. In her early 50s, she was not very active, but later she began walking daily and joined a fitness group. By her 60s, exercise had become part of her routine, and she felt healthier and more energetic. She often told her friends that although she wished she had started earlier, she was glad she did not wait longer. In the end, the researchers realized that health is not shaped by one decision but by habits repeated over time. Emma's journey, along with thousands of others, showed that physical activity is not just about staying fit today, but about building a healthier future step by step, with benefits that continue to grow throughout life.

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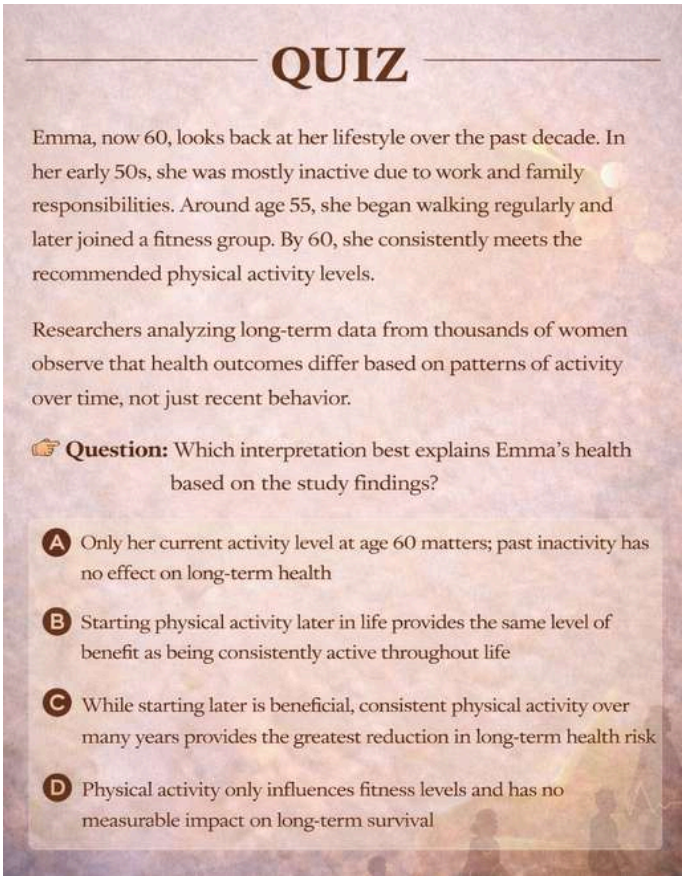
Prevention Research Collaboration, Sydney School of Public Health, Faculty of Medicine and Health, The University of Sydney, Camperdown, Australia, Charles Perkins Centre, The University of Sydney, Camperdown, Australia.



| By Dr. Priyangana Deb

THE LIGHTS THAT TELL A STORY

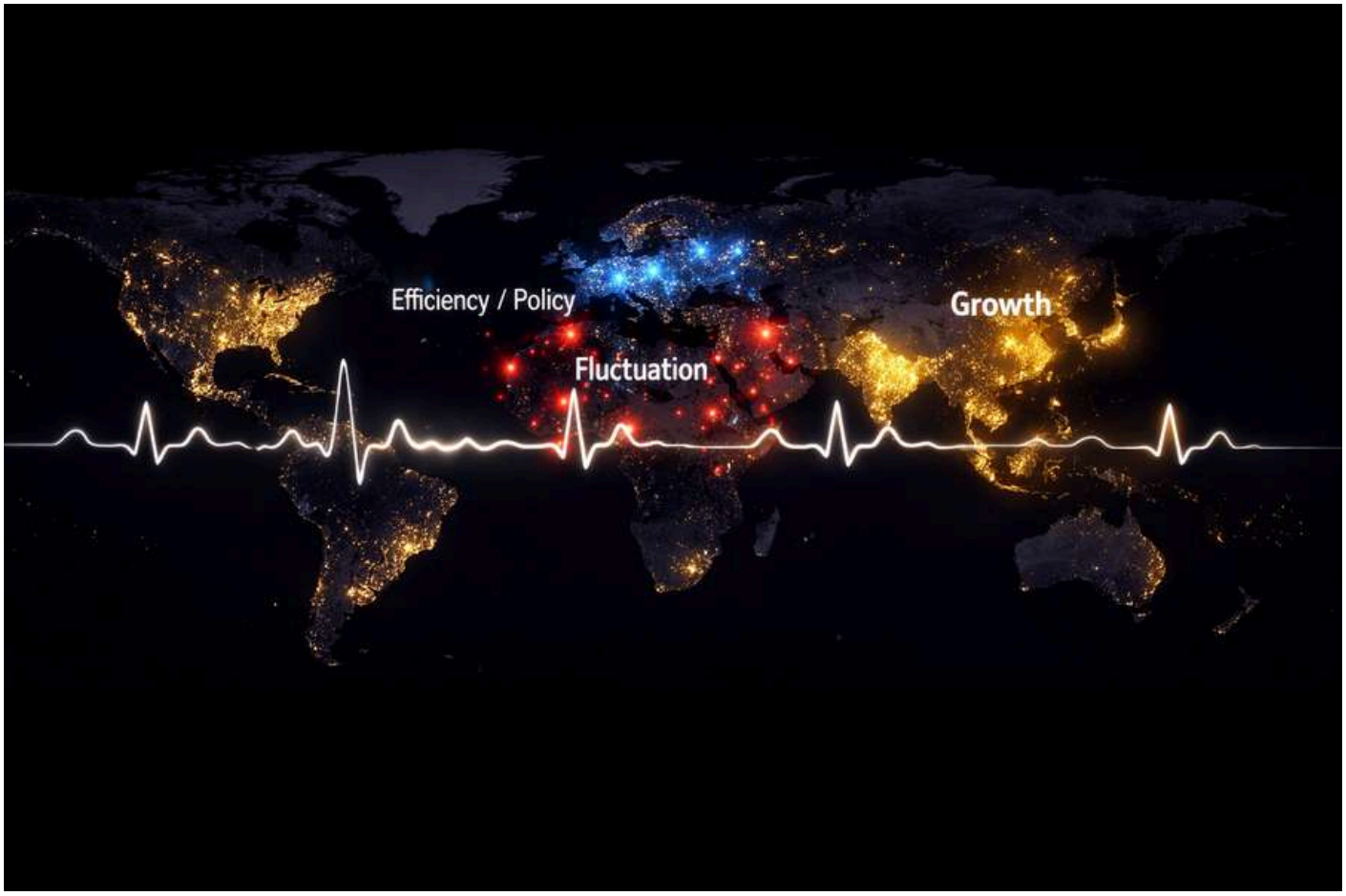
In a research lab in the United States, Dr. Maya Singh spent her nights studying images of Earth from space. But she wasn't looking at mountains or oceans, she was studying lights. The glowing patterns of cities, roads, and towns at night showed how people live and use energy. "These lights tell us about human activity," she explained to her team Alex Carter, a data analyst, and Lina Chen, a satellite specialist. To them, every bright spot on the map represented human presence, movement, and development, like a living map of the world.

For many years, scientists believed Earth was slowly becoming brighter at night, based on yearly or monthly satellite images. But Maya wondered if something was missing. To find out, the team used NASA's "Black Marble" dataset, which provides daily images of Earth at night. Instead of averages, they studied day-by-day changes from 2014 to 2022. It was like switching from a blurred picture to a clear video, allowing them to see short-term changes that were previously hidden.

As Alex analyzed the data, he noticed something surprising. "The lights are not just increasing, they are changing all the time," he said. Many places were becoming brighter and dimmer again and again. On average, each location had about 6 to 7 changes over nine years. This showed that human activity is more dynamic than expected and constantly shifting.

Lina examined different regions. Some areas suddenly became brighter or darker. The team identified two types of changes. Sudden changes happen due to events like construction, disasters, or power outages. Gradual changes happen due to city growth or increasing energy use. Around 2 million square kilometers experienced sudden changes, while about 19 million square kilometers showed gradual changes, showing how widespread these patterns are.

Maya explained the reasons behind these patterns. "Brightening usually means development," she said.



| By Dr. Priyangana Deb

This was clear in Asia and Africa, where cities are growing quickly. Dimming had different meanings. In Europe, it was often due to energy-saving policies and efficient lighting. In places like Venezuela, it reflected economic problems and failing infrastructure. The team realized that the same change like dimming could mean very different things depending on the region.

The team also saw differences between countries. China and India showed strong brightening due to rapid development. Europe showed dimming because of energy-saving efforts. In the United States, some regions became brighter while others dimmed due to industrial changes and improved efficiency. These differences helped the researchers understand how policies, economies, and technologies shape human activity.

Alex pointed out regions with strong ups and downs. These were oil-producing areas where activity changes quickly. When production increases, lights brighten; when it slows, they dim. “It’s like a pulse,” Lina said, comparing it to a heartbeat that rises and falls with economic activity.

They also found that some changes were strong and sudden, especially in fast-growing cities, while others were slow and steady, like suburban expansion. After 2020, changes became more frequent. Global events like COVID-19, energy crises, and policy changes had a strong impact. Lockdowns caused many cities to dim temporarily, clearly showing how human activity affects night-time light.

Looking at the glowing Earth, Maya said, “This is like a heartbeat of human activity.” Every change in light told a story of growth, crisis, and recovery. The team realized that night-time light is a powerful way to understand how the world is changing and how societies respond to challenges.

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| By Dr. Sudha Shankar

THE FOREST THAT CAME BACK TO LIFE

Deep in the tropical forests of Ecuador, Dr. Lucas Moreno stood at the edge of a clearing that had once been a dense rainforest. Years ago, this land had been cut down and used for farming. Now, small trees and plants were growing again, slowly trying to reclaim what was lost. “Can a forest truly come back to life?” he wondered.

Lucas was part of a research team studying how forests recover after human disturbance. His colleagues Dr. Sofia Marquez, an ecologist, and Daniel Cruz, a young field researcher had been working together to understand how nature heals itself. They were not just studying trees, but also birds, insects, mammals, frogs, and even tiny bacteria in the soil. “A forest is more than trees,” Sofia often said. “It is a whole living system.”

To understand this, the team studied different types of land. Some areas were still being used for farming, some had been left to recover for a few years, and others had been growing back for decades. They also studied untouched forests, known as old-growth forests, to see what a fully healthy forest looks like. These served as their reference.

One morning, as they walked through a young forest that had been recovering for about 10 years, Daniel pointed at the trees. “Look, there are so many plants already growing,” he said excitedly. The forest looked green and lively, but Lucas shook his head gently. “Yes, it looks alive,” he said, “but we need to check what kind of life has returned.”

Back at their research station, they analyzed the data they had collected from 62 different plots of land. The results were surprising. After about 30 years, many forests regained more than 90% of their total number of species and individuals. “That means nature is very strong,” Sofia explained. “It can recover much of what was lost.”

“But not everything,” Lucas added. When they looked closer, they found that the types of species were still different from the original forest. Only about 75% of the original species had returned. “So even if the forest looks

| By Dr. Sudha Shankar

full," Daniel said, "it is not exactly the same as before."

As they continued their work, they noticed something even more interesting. Different organisms recovered at different speeds. Birds, bats, and bees returned quickly because they could fly and move easily from one place to another. These animals played an important role in spreading seeds and pollinating plants, helping the forest grow faster. "They are like the forest's helpers," Sofia smiled.

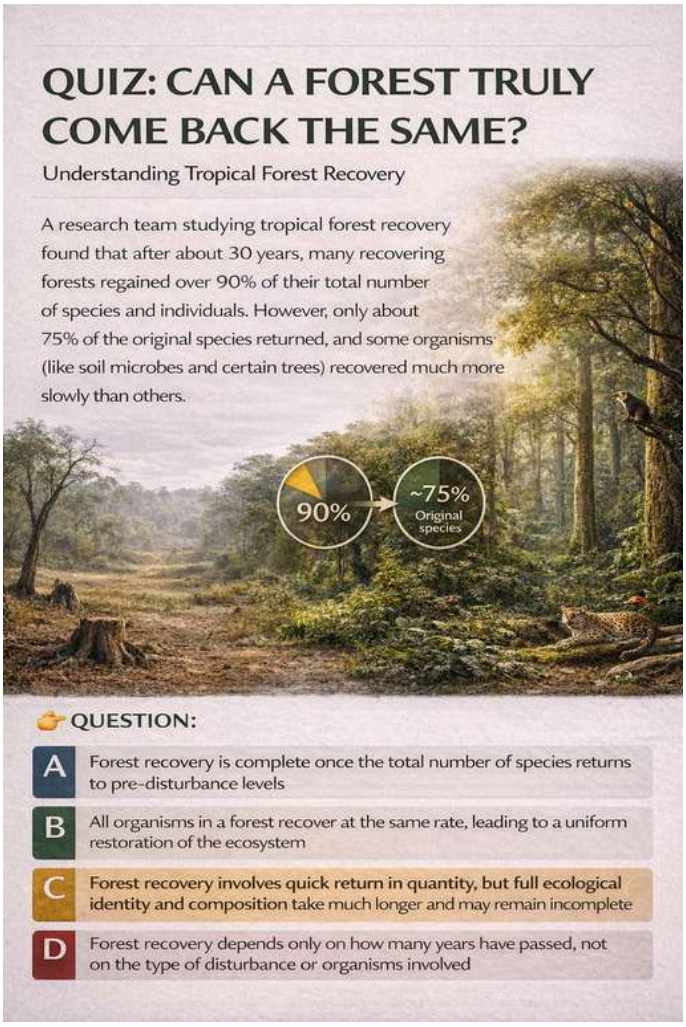
But trees told a different story. They took much longer to recover because they grow slowly and need many years to mature. Some species of trees were still missing even after decades. Even slower were the tiny organisms in the soil, like bacteria, which showed almost no recovery in some areas. "The smallest life forms can take the longest to heal," Lucas noted.

The team also found that not all land recovered in the same way. Forests that grew back after cacao farming recovered faster than those that came back after pasture land. "Cacao farms still have some trees and shade," Daniel explained, "but pastures are more damaged." This difference made it harder for life to return in some areas.

One evening, as the sun set over the forest, Lucas explained an important idea to Daniel. "Recovery is not just about what survives," he said. "It's about how quickly life returns." They had discovered that the speed at which species came back was more important than how many survived the disturbance.

Over time, the team realized that forest recovery is a slow and complex process. Some parts of the ecosystem recover quickly, while others take decades or even centuries. The forest is like a puzzle, where each piece returns at its own pace. Standing in a part of the forest that had been recovering for nearly 30 years, Sofia looked around and smiled. Birds were calling, insects were buzzing, and young trees stretched toward the sky. "It may not be perfect yet," she said, "but it is alive again."

Lucas nodded. "This gives us hope," he said. "If we protect these forests and give them time, they can heal themselves." And as the forest whispered with life once more, the team understood something deeply important nature has the power to recover, but only if we allow it the time and space to do so.



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| SCIENCE DESK |

THE STORY BEHIND A BENT-CORE NICKEL COMPLEX: WHERE MOLECULAR DESIGN MEETS BIOMOLECULAR RECOGNITION

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Areas of Expertise: Liquid Crystals | Organic functional materials | Soft matter | Photoresponsive Materials

What first inspired you to design and study bent-core Schiff base ligands and their nickel complexes, and how did this research begin?

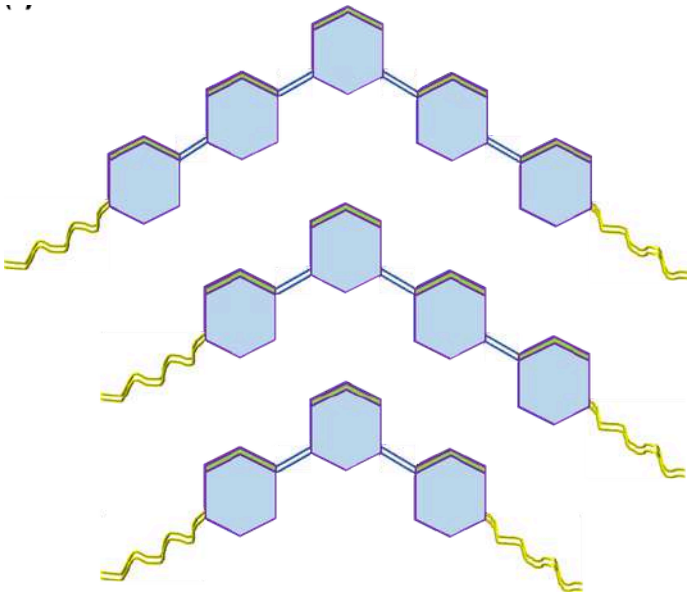
The concept of bent-core (or bent-shaped) molecular design (Figure 1) originates from liquid crystal research, where molecular shape plays a decisive role in determining mesomorphic behavior. A pioneering study by Hideo Takezoe and his group at Tokyo Institute of Technology demonstrated that non-linear, banana-shaped molecules can exhibit liquid crystalline phases, expanding the scope beyond conventional rod-like mesogens. This discovery significantly accelerated research in bent-core liquid crystals (BLCs). In India, Nandiraju V. S. Rao and his research group at Assam University, Silchar developed a unique class of asymmetrical bent-core systems, characterized by an uneven distribution of phenyl rings around a 1,3-disubstituted central aromatic core. These systems typically consist of four phenyl rings and exhibit bend angles in the range of 140°–160°, and are commonly referred to as short bent-core systems. As a member of this research group, work has been carried out on designing even more compact architectures, including three-ring bent-core molecules, which represent some of the shortest systems in this category. In addition, efforts have been made to synthesize metal complexes of such ligands with transition metals like copper, zinc, and iron to investigate how the bent molecular framework influences coordination behavior and whether liquid crystalline properties are retained or new functionalities emerge. Recently, a Ni(II) complex based on a very short bent-core ligand has been successfully developed, showing interesting structural and physicochemical properties.

Can you explain in simple terms what makes this bent-core nickel complex special and different from other metal complexes?

The shape of the ligand is bent which is not typical as other common ligands. And due the bent geometry of the ligand molecules it is not easy to form complexes. But at the same due the bent shape the electronic polarizability and electrochemical properties are different as compared to typical longitudinal or flat ligand.

Your study explores DNA and protein binding why is this important for chemistry, biology, and possible medicinal applications?

Studying the binding of metal-based complexes with DNA and proteins is important in chemistry, biology, and medicine because it provides insight into their structural and electronic behavior, helping in the rational design of stable and functional compounds. Biologically, interactions with essential biomolecules like DNA and serum albumins (HSA/BSA) reveal how these complexes are transported, distributed, and recognized within living systems. From a medicinal perspective, DNA binding is especially significant since many anticancer drugs act by targeting DNA to inhibit cell growth, while protein binding enhances drug solubility, reduces toxicity, and improves delivery through the bloodstream. Overall, understanding these interactions is crucial for developing effective, selective, and safer therapeutic agents.



Bent-core systems (a) Symmetric bent-core system, (b) Asymmetric bent-core system, (c) Short bent-core system

| SCIENCE DESK |

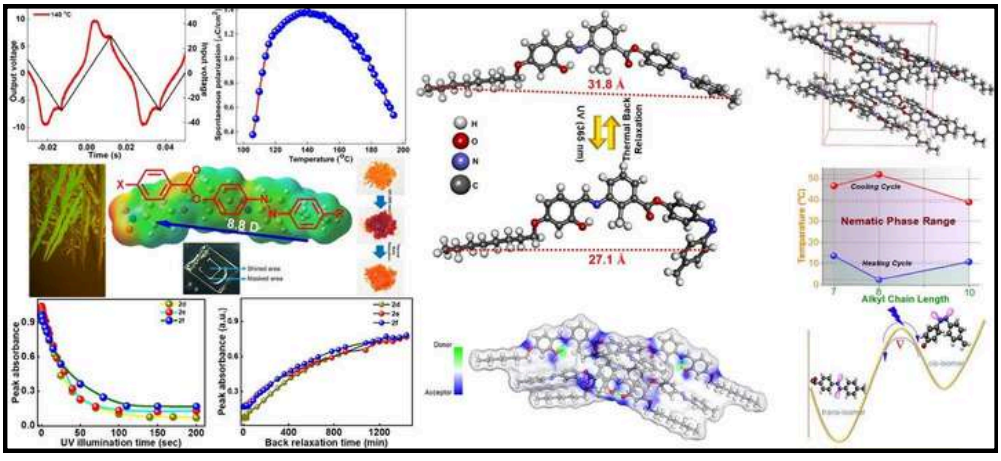
THE STORY BEHIND A BENT-CORE NICKEL COMPLEX: WHERE MOLECULAR DESIGN MEETS BIOMOLECULAR RECOGNITION

What surprised you the most during the structural, computational, or biomolecular studies of this complex?

The most surprising observation from this study was the strong and sensitive biomolecular interaction behavior of the Ni(II) complex despite its relatively simple square-planar structure. In particular, the complex exhibited very low detection limits (0.075–0.188 μM) toward DNA, BSA, and HSA along with a clear fluorescence red-shift response, indicating highly efficient biomolecular recognition. Additionally, the significant binding affinity with BSA (−8.52 kcal/mol) revealed through molecular docking, supported by multiple non-covalent interactions, was notably high. From a computational perspective, the presence of a moderate HOMO–LUMO gap (4.00 eV) combined with strong ligand-to-metal charge transfer was also striking, as it reflects a rare balance between stability and reactivity. Altogether, the combination of strong binding, high sensitivity, and favorable electronic properties was an unexpected and noteworthy outcome of the study.

Do you think this type of molecule could have future applications in sensing, drug design, or biomedical research?

Indeed, this type of molecule is highly promising for future applications across sensing, drug design, and biomedical research. Its ability to produce distinct and measurable fluorescence responses upon interaction with biomolecules makes it suitable for developing sensitive detection platforms. At the same time, the strong and stable binding with DNA and serum proteins highlights its relevance in therapeutic development, particularly for designing agents that can effectively target and transport within biological systems. Furthermore, its favorable electronic structure and stability support its functionality in complex biological environments. Collectively, these properties suggest that such complexes could play an important role in next-generation diagnostic tools, targeted drug systems, and bio-related research technologies.



Dr. Golam Mohiuddin,s work is reflected in their work published in *RSC Advances* (2026). https://doi.org/10.1039/D5RA07894F

What are the next steps, and what still needs to be studied before we fully understand the practical potential of this system?

Although the study reveals promising structural, electronic, and biomolecular properties of the Ni(II) complex, several further investigations are required to fully understand its practical potential. Detailed biological studies, including in vitro cytotoxicity, selectivity, and mechanism of action, are necessary to confirm its therapeutic relevance, followed by in vivo evaluations to assess pharmacokinetics, bioavailability, and toxicity under physiological conditions. More advanced biophysical techniques are also needed to precisely determine the mode of DNA and protein binding beyond preliminary fluorescence and docking results. In addition, computational studies such as molecular dynamics simulations would provide deeper insight into stability in biological environments, while systematic structure–activity relationship modifications could help optimize performance. Finally, for sensing applications, parameters like selectivity, interference, and real-sample applicability must be evaluated, making these combined efforts essential to translate this system into effective biomedical or diagnostic use.

| SCIENCE DESK |

DESIGNING NEW MOLECULES TO FIGHT MICROBES AND VIRUSES

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| Scientific Profile |
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Areas of Expertise: Green Synthetic Chemistry | Computational Chemistry | Drug Design & Discovery | Pharmacophore site identification

What inspired you to design and study these new thiazolidinedione–pyrrole hybrid molecules, and how did this research idea begin?

The design and investigation of novel thiazolidinedione–pyrrole hybrid molecules were inspired by the urgent need to develop effective therapeutic agents against microbial and viral infections, particularly in the face of increasing drug resistance. Thiazolidinedione and pyrrole are well-established pharmacophores, each associated with diverse biological activities such as antimicrobial, antiviral, anti-inflammatory, and anticancer effects. The integration of these two moieties into a single molecular framework was guided by the concept of pharmacophore hybridization, aiming to enhance biological potency, improve selectivity, and minimize resistance.

This research idea emerged from a comprehensive literature survey, which highlighted the individual significance of both scaffolds but revealed limited studies on their combined potential. This gap provided a strong rationale for designing hybrid derivatives with improved pharmacological profiles. Microwave-assisted synthesis was employed as an efficient and green synthetic approach, offering reduced reaction times, higher yields, and cleaner reaction conditions.

In addition to experimental synthesis and biological evaluation, advanced computational techniques were incorporated to strengthen the study. Density Functional Theory (DFT) calculations were performed to optimize molecular geometries and analyze electronic properties, providing insights into reactivity and stability. Furthermore, Petra/Osiris/Molinspiration (POM) analysis was utilized to predict drug-likeness, toxicity risks, and pharmacokinetic behavior of the designed compounds. Molecular docking studies complemented these approaches by evaluating binding interactions with relevant biological targets. Overall, this multidisciplinary strategy integrates synthetic chemistry, biological screening, and computational modeling, including DFT and POM analyses, to facilitate the rational development of novel antimicrobial and antiviral agents.

Can you explain in simple terms what these newly synthesized compounds are and why they are scientifically important?

The newly synthesized thiazolidinedione–pyrrole hybrid compounds, specifically N-substituted thiazolidine-2,4-dione derivatives bearing a pyrrole-2,5-dione moiety, are designed by combining two biologically active molecular structures into a single entity to enhance their therapeutic potential. The target drug contains a heterocyclic five-membered ring of nitrogen and sulphur atoms, which are known to play a crucial role in biological activities. Thiazolidinedione and pyrrole are both recognized for their antimicrobial, antiviral, and other pharmacological properties. By merging these two scaffolds, the resulting hybrid molecules are expected to exhibit improved biological activity, better selectivity, and reduced chances of drug resistance.

These compounds are scientifically important because they offer a promising approach to developing new drugs against resistant microbial and viral infections, which remain a major global health concern.

Your study highlights antibacterial, antifungal, and possible antiviral potential. Why is it important today to develop such multifunctional molecules?

The development of multifunctional molecules with antibacterial, antifungal, and antiviral activities is critically important in the current era due to the rapid emergence of drug-resistant pathogens and the increasing incidence of co-infections. According to the World Health Organization, antimicrobial resistance (AMR) is one of the top global health threats, responsible for millions of deaths annually. In addition, viral outbreaks such as COVID-19 have demonstrated the urgent need for broad-spectrum therapeutics.

Multifunctional molecules offer a strategic advantage by targeting multiple pathogens or biological pathways simultaneously, thereby reducing the likelihood of resistan-

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ce development and improving therapeutic efficacy. Scientific studies have shown that hybrid compounds containing heteroatoms like nitrogen and sulphur enhance binding interactions with microbial enzymes and viral proteins, leading to improved bioactivity. Furthermore, such compounds can minimize the need for combination therapies, reducing drug interactions and side effects. Therefore, the design of these multifunctional agents represents a rational and evidence-based approach to addressing complex infectious diseases in modern medicinal chemistry.

What was the most exciting or surprising finding during the synthesis or biological evaluation of these compounds?

One of the most exciting findings during the synthesis and biological evaluation of these thiazolidinedione–pyrrole hybrids was the observation that certain derivatives exhibited significantly enhanced antimicrobial activity compared to expected outcomes. In particular, some N-substituted thiazolidine-2,4-dione derivatives bearing a pyrrole-2,5-dione moiety showed strong antibacterial and antifungal effects even at lower concentrations, suggesting a synergistic effect arising from the hybridization of the two pharmacophores.

Another notable and somewhat surprising result was the correlation between electronic properties (revealed through DFT studies) and biological activity. Compounds with favorable electron distribution and optimized frontier molecular orbitals demonstrated better interaction with biological targets, which was further supported by molecular docking studies. Additionally, POM analysis indicated good drug-likeness and low predicted toxicity for the most active candidates, reinforcing their potential as lead molecules.

Importantly, the study successfully identified targeted compounds exhibiting significant antiviral/anti–SARS-CoV-2 potential, highlighting their relevance in addressing emerging viral threats. From a synthetic perspective, the efficiency of microwave-assisted synthesis was also remarkable, providing high yields and reduced reaction times without compromising product purity. Overall, the convergence of strong biological activity with supportive computational predictions was both encouraging and scientifically significant.

How does microwave-assisted synthesis help in modern drug discovery, and why is this approach useful compared to traditional methods?

Microwave-assisted synthesis has become an important tool in modern drug discovery because it enables the rapid and efficient preparation of novel compounds. Unlike traditional heating methods, which rely on slow heat transfer, microwave irradiation directly interacts with molecules, leading to uniform and accelerated heating. As a result, chemical reactions that typically take several hours or even days can be completed within minutes.

This approach offers several advantages over conventional methods. It significantly reduces reaction time, increases product yield and purity, and often minimizes the formation of unwanted byproducts. These benefits are particularly valuable in medicinal chemistry, where large libraries of compounds need to be synthesized and screened quickly. Additionally, microwave-assisted synthesis supports green chemistry principles by lowering energy consumption and reducing the use of hazardous solvents.

From a drug discovery perspective, this method allows researchers to rapidly optimize reaction conditions and generate diverse molecular scaffolds, accelerating the identification of potential lead compounds. Overall, microwave-assisted synthesis enhances efficiency, sustainability, and reproducibility, making it a highly useful and preferred approach compared to traditional synthetic techniques.

What are the next steps for this work, and what still needs to be studied before such compounds could move closer to real therapeutic applications?

The present study establishes N-substituted thiazolidine-2,4-dione–pyrrole hybrids as promising lead compounds; however, several critical steps are required before their translation into therapeutic agents. First, comprehensive in vitro mechanistic studies must be conducted to elucidate precise molecular targets, enzyme inhibition pathways, and antiviral modes of action, particularly against SARS-CoV-2–related proteins. This should be followed by in vivo pharmacological evaluations to assess efficacy, dose–response relationships, and toxicity profiles in suitable animal models.

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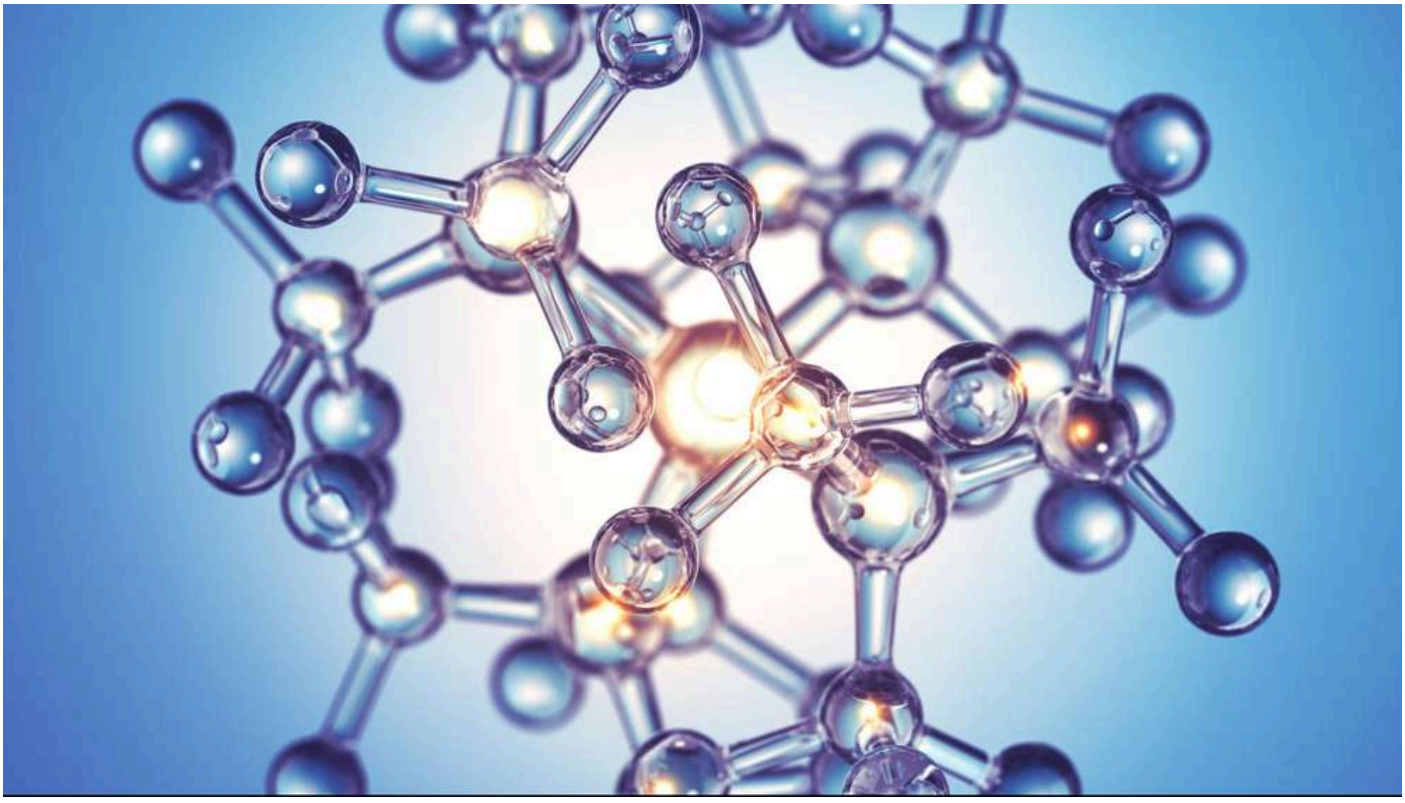
Further, detailed pharmacokinetic and pharmacodynamic (PK/PD) studies are essential to determine absorption, distribution, metabolism, excretion, and bioavailability. Structural optimization through structure–activity relationship (SAR) studies is also necessary to enhance potency and selectivity while minimizing off-target effects. Although preliminary computational analyses (DFT and POM) indicate favorable properties, these predictions must be validated experimentally.

In addition, long-term toxicity, genotoxicity, and safety pharmacology assessments are required to ensure clinical safety. Finally, scale-up synthesis, formulation development, and stability studies must be addressed to support potential clinical trials. Collectively, these steps are crucial to bridge the gap between early-stage discovery and real therapeutic application.

Dr. Bhat's contribution to this filed is reflected in their work published in *Scientific Report* (2026). https://doi.org/10.1039/D5RA07894F



| SCIENCE DESK |

WHY SOME PARTS OF A CITY PRODUCE MORE GARBAGE THAN OTHERS

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Kota, India
| Scientific Profile |
| Organization Link |
| Factors Press |
Areas of Expertise: GIS-based Spatial Analysis | Urban Waste Management | Multi-Criteria Decision-Making (MCDM) | Environmental Planning

What first inspired you to study the relationship between city design and waste generation, and how did this research begin?

The idea began with a simple observation waste is not evenly distributed across a city. While examining different wards of Kota, some areas consistently showed much higher waste accumulation than others. This raised an important question: is waste generation only a function of population, or does the way a city is structured also play a role?

This curiosity led to exploring waste generation from a spatial perspective, focusing on how different parts of the city behave differently based on land use, population density, and urban activity patterns.

Can you explain in simple terms why different parts of a city produce different amounts of garbage?

Different parts of a city serve different purposes. In Kota, areas dominated by dense residential settlements and mixed land use tend to generate higher amounts of waste, while peripheral or less developed areas produce much less.

In simple terms, waste depends on what activities are taking place in a particular area. Residential zones generate regular household waste, commercial areas such as markets produce large volumes in shorter periods, and mixed-use areas combine multiple activities, leading to even higher waste generation.

Your study shows that land use and population density influence waste generation—why is this important for city planning and waste management?

These findings highlight that waste generation is closely linked to land-use patterns and population density. However, many cities still rely on uniform waste management strategies, assuming that all areas generate similar amounts of waste.

In reality, some wards generate several times more waste than others. This means planning needs to be location-specific. High-density and mixed-use areas require more frequent collection and better infrastructure, while low-density areas may need fewer resources. Such targeted planning can improve efficiency, reduce costs, and support more sustainable waste management.

What surprised you the most when you mapped waste generation across different wards of Kota city?

One of the most striking observations was the clear spatial clustering of waste generation. Instead of being randomly distributed, high waste generation was concentrated in specific wards, particularly those with dense population and mixed land use.

There was also a large variation between wards. Some areas generated several times more waste than others within the same city. This clearly showed that urban structure plays a major role in shaping waste patterns.

Do you think studies like this can help cities become cleaner, more efficient, and more sustainable in the future?

Yes, definitely. Such studies provide a more realistic, data-driven understanding of how cities function. By identifying where waste is generated most intensely, city authorities can allocate resources more effectively and reduce inefficiencies.

Integrating spatial analysis into waste management can help cities move from reactive approaches to more planned and efficient systems, ultimately contributing to cleaner and more sustainable urban environments.

What are the next steps, and what still needs to be explored to better manage waste in rapidly growing urban areas?

The next step is to move toward dynamic and real-time waste management systems. Cities are constantly evolving, and waste generation patterns change over time. Integrating geospatial analysis with data analytics and emerging technologies can help monitor and predict these changes more effectively.

There is also a need to better understand how socioeconomic factors, lifestyle patterns, and seasonal vari-

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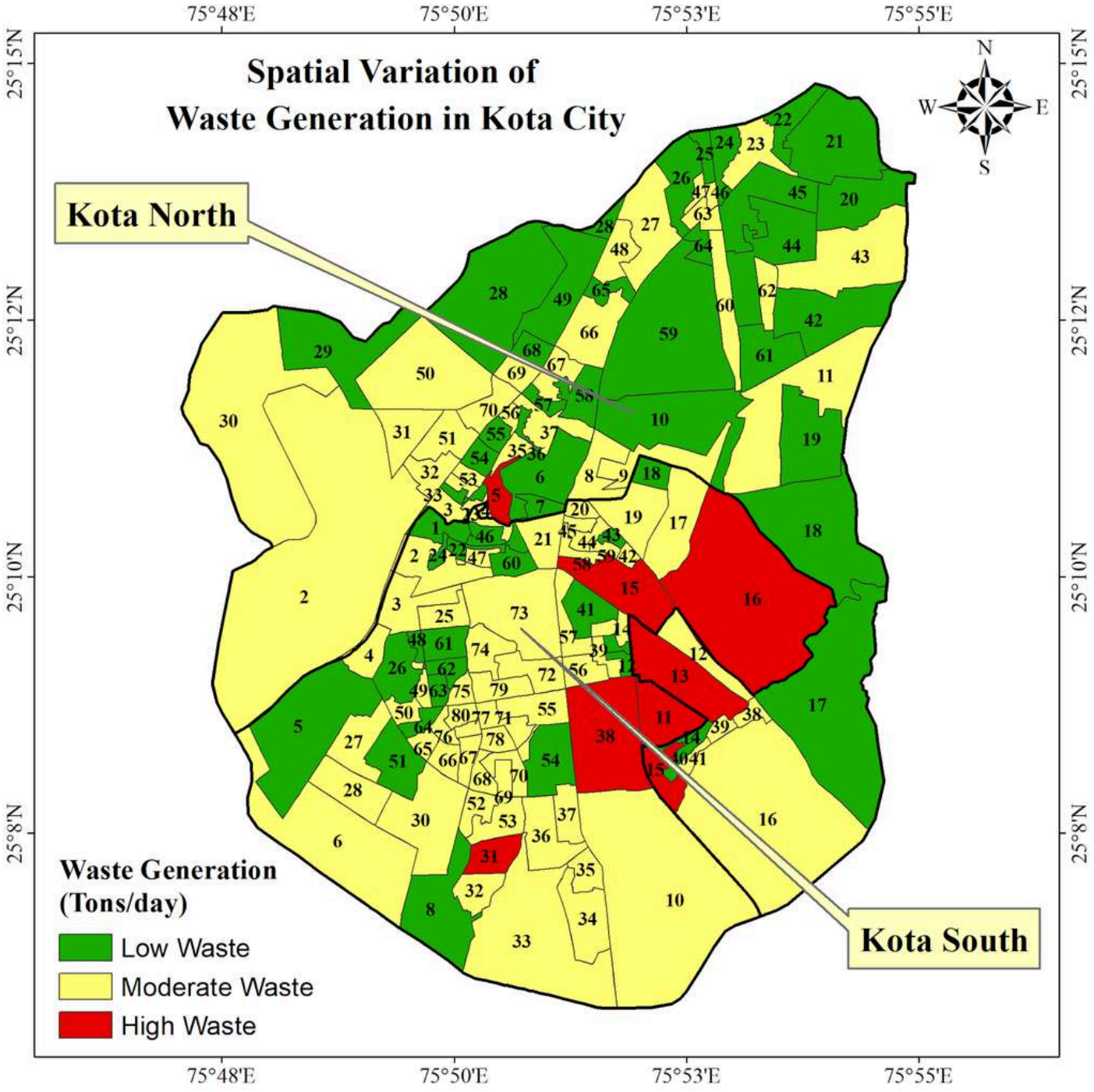
WHY SOME PARTS OF A CITY PRODUCE MORE GARBAGE THAN OTHERS

ations influence waste generation. Developing integrated decision-support systems that connect urban planning, waste management, and environmental sustainability will be essential for managing waste in rapidly growing cities.

Dr. Kumar's contribution to this filed is reflected in their work published in *Integrated Environmental Assessment* and Management (2026).



| SCIENCE DESK |

CAN AI HELP CREATE SAFE SPACES FOR MENTAL HEALTH?

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| Scientific Profile |
| Organization Link |
| Factors Press |

Areas of Expertise: Mental Health | Behavioral Sciences

Can artificial intelligence help create safe and supportive spaces for mental health care?

The short answer to this question would be "yes". The long answer, however, is comprehensive and convoluted. Let us answer this question by posing more questions, the age-old method of teaching and learning.

What is artificial intelligence, and how is it defined in modern science?

John McCarthy, known as the founding father of AI, in a very interesting technical report titled "Making Robots Conscious of their Mental States", describes it as a process of creating machines that can act in ways that would be considered intelligent if exhibited by humans. In other words, the goal of artificial intelligence is to build systems that behave as though they possess intelligence.

How does artificial intelligence function, particularly in the context of healthcare applications?

Machine Learning (ML) is an important component of AI whereby the machine learns from the data by creating algorithms that continue to learn and perform. It is taught to recognise patterns and construct data points, which enable calculated future predictions. When it comes to health care, AI can analyse patient data and electronic health records (EHRs) to aid in diagnosis and customise treatment plans based on the information it is provided. AI has the invaluable advantage of not missing even the most minute of details and understanding connections that exist on the thinnest of threads, which the human eye and brain might not comprehend. Natural Language Processing (NLP) is another branch of AI which enables machines to interpret and generate natural language. It can analyse pages and pages of clinical data and a huge number of laboratory and radiology reports; extract information and learn from it; and provide clinicians with palatable and usable insights.

What role does artificial intelligence play in mental health care?

Apart from using digital phenotyping (personal sensing) and NLP to detect changes in the patterns of behaviour and mood of patients, another important use of AI in mental health care is through chatbots. Chatbots can identify mental health concerns by asking questions about aspects such as mood, stress, energy levels, and sleep patterns. In a country like India, where there is a huge care gap with only a handful of mental health professionals available for a section of the population, these chatbots can greatly help in bridging this gap. Based on the responses, the chatbot can analyse the information and recommend appropriate interventions, ranging from behavioural strategies (physical activity, meditation, relaxation techniques, etc.) to advising consultation with a healthcare professional when medication may be necessary. In situations where there is a potential risk to the patient or others, the chatbot may also alert a medical provider.

In what ways can artificial intelligence be used to create safe mental health environments?

AI-powered tools such as chatbots (Woebot, Talkspace, etc.), emotional health apps (Moodfit, Happify, etc.), and smart mental health tools (Kintsugi, Cerebral, etc.) are transforming the mental health landscape by providing accessible, stigma-free platforms for personalised assessments and customised care plans. These tools can offer continuous, on-demand support regardless of time or location. This helps bridge critical gaps in service availability, allowing individuals to seek assistance whenever needed. Crisis services have also begun integrating these tools, which can engage users empathetically, suggest coping strategies, and escalate to human professionals or helplines when necessary.

Additionally, AI-driven systems can simultaneously support multiple users and have been adapted for specialised populations, such as children and the elderly, where they assist in developing specific skill sets. Overall, advances in conversational AI allow these tools to provide empathetic engagement, emotional support, and a broader range of accessible mental health resources.

What precautions should be taken to ensure that AI-based mental health spaces are truly safe and effective?

Preserving the human aspect of therapy while using AI as a

CAN AI HELP CREATE SAFE SPACES FOR MENTAL HEALTH?

supportive tool is an important precaution to be taken. Rather than replacing mental health professionals, AI should complement and strengthen the therapeutic relationship. Achieving an appropriate balance between AI-based interventions and human involvement is therefore essential.

It is of utmost importance that the patients are clearly informed when AI tools are incorporated into their care. Such transparency enables them to make informed decisions about choosing or not choosing AI involvement and understand the extent of the involvement in their treatment. Additionally, although AI can continuously monitor and detect changes in behaviour, this process should be guided by human oversight. Clinicians must interpret and act on these insights, ensuring that care remains centred on human judgement and connection and not entirely left to the AI, which at its base is still a machine capable of errors.

What are the key concerns associated with the use of artificial intelligence in mental health care?

The use of AI in mental health care requires robust safeguards to protect patient data and maintain confidentiality. As it deals with sensitive information such as medical histories, therapy records, and behavioural data, it must be secured against unauthorised access and breaches. AI-based platforms should comply with regulations like the Health Insurance Portability and Accountability Act (HIPAA) of 1996 to ensure secure storage and transmission of patient data, thereby preserving privacy. Ethical implementation of AI also involves clarifying where the data stores and who owns it and obtaining informed consent, ensuring that individuals retain control over their information and understand how it will be used in AI-driven care.

AI systems can reflect and perpetuate biases embedded in their training data, which may result in unequal diagnostic outcomes or treatment recommendations. It is therefore essential to recognise and address these biases to promote fairness and ensure equitable care across all populations.

Dr. `Vibha's contribution to this filed is reflected in their work published in *Asian Journal of Psychiatry* (2026) https://doi.org/10.1016/j.ajp.2026.104925

What is the future direction of artificial intelligence in mental health care, and how can it be integrated effectively?

Integrating AI tools into existing systems of mental health care can enhance clinical efficiency. For example, natural language processing can examine therapy conversations to identify subtle indicators of mental health conditions. AI can also support more precise treatment approaches by predicting patient responses based on patterns observed in similar cases, reducing reliance on trial-and-error methods.

A few potential future directions in mental healthcare could involve hybrid models that integrate physical spaces with AI-enabled support systems. Within these environments, individuals might engage with multilingual, culturally sensitive interfaces capable of guiding them through their difficulties. These systems could incorporate multimodal features to enhance accessibility for users with varying levels of literacy or familiarity with digital tools. An AI-driven triage component could potentially help identify user needs and direct them toward appropriate forms of support. Interfaces integrating biometric feedback through wearable devices, enabling real-time adaptation of interventions based on physiological signals such as stress or sleep patterns. Additional possibilities include integration with telepsychiatry services, community-based outreach programs, and mobile versions for rural and underserved areas.

While still speculative, such models reflect a broader shift toward combining technological innovation with human-centred design. They suggest a future in which mental healthcare becomes more accessible, adaptive, and context-sensitive, while still maintaining pathways to professional, human-led intervention when needed.

AI in future of mental health care

| SCIENCE DESK |

HOW BANANA ROOTS MAY HELP FIGHT A DEADLY WILT DISEASE

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Areas of Expertise: Plant-microbe interaction | Fungal disease in plants | Molecular Plant Pathology

What first inspired you to study banana root exudates and their role in Fusarium wilt disease?

Fusarium wilt is a major disease affecting many horticultural crops and poses a serious threat to global agriculture. Members of Fusarium oxysporum have co-evolved closely with their hosts, resulting in high host specificity where individual strains infect only particular species or cultivars. This specialization has led to their classification into formae speciales (f. sp.) and further into races. Banana, a key crop in tropical and subtropical regions and especially important in developing countries, is highly vulnerable to this disease. India, the world's largest banana producer, faces significant yield losses due to Fusarium wilt caused by Fusarium oxysporum f. sp. cubense (Foc), which is widespread across banana-growing areas. Different Foc strains exhibit cultivar-specific interactions, infecting susceptible varieties while resistant ones remain unaffected, indicating a precise host-pathogen recognition mechanism. Plants, including banana, release a complex mixture of metabolites and proteins into the rhizosphere through root exudates. These exudates play a crucial role in shaping the root microbiome by attracting beneficial microorganisms. However, these chemical signals are not exclusive to beneficial microbes and can also be detected by pathogens. As a result, pathogens may engage in a molecular dialogue with the host, either actively or passively, which can facilitate colonization and disease progression depending on spatial and temporal factors. Based on this background, this study aimed to determine whether root exudates from different banana cultivars possess distinct biochemical profiles that influence Foc behaviour. Specifically, the objective was to assess how these exudates affect key developmental stages of the pathogen, including spore germination, hyphal growth, and chemotaxis. Additionally, the study sought to understand whether such exudate-mediated interactions contribute to early host-pathogen communication, potentially shaping infection outcomes before physical contact occurs

Can you explain in simple terms what root exudates are and why they are important in plant-microbe interactions?

Root exudates are complex mixtures of carbon-based compounds secreted by plant roots, comprising both low-molecular weight (such as sugars, amino acids, and organic acids) and high-molecular weight compounds, including proteins. These exudates play a crucial role in belowground nutrient cycling and form a dynamic interface between the plant, soil, environment, and associated microbial communities. Organic acids released in root exudates facilitate the solubilization and mobilization of essential minerals, thereby enhancing nutrient availability. In addition, these chemical signals actively recruit beneficial microorganisms, promoting mutualistic interactions that support plant growth, health, and sustainability. Root exudates can also exhibit inhibitory effects against various soil-borne pathogens and contribute to improving overall soil vitality. Importantly, both the quantity and composition of root exudates are highly variable and are influenced by multiple factors such as environmental conditions, plant species, and developmental stage. These root-derived chemical signals are not exclusively perceived by beneficial microorganisms but, soil-borne pathogens present in the vicinity can also detect and respond to them. Over evolutionary timescales, selective pressures have shaped pathogen populations to recognize specific molecular cues within the complex biochemical profiles of root exudates. This has enabled pathogens such as Foc to identify suitable host plants with a high degree of specificity. While the downstream mechanisms that pathogens use to overcome, host defenses have diversified and adapted over time, the initial stages of host recognition via root exudate signals appear to remain relatively conserved.

Your study compares resistant and susceptible banana cultivars-what did you find most interesting about how their root exudates affected the pathogen?

We hypothesized that resistant and susceptible banana cultivars release qualitatively and quantitatively different sets of metabolites into the rhizosphere. These differences may act as selective signals that either attract or repel Foc, modulate its virulence, or alter its ability to recognize and

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infect the host. In susceptible cultivars, root exudates may contain compounds that inadvertently stimulate pathogen growth or facilitate host recognition whereas, resistant cultivars may produce exudates that inhibit pathogen activity, disrupt signalling pathways, or fail to provide the cues necessary for successful colonization. By characterizing the metabolomic composition of root exudates and assessing their functional properties on Foc, we aim to uncover key biochemical determinants underlying cultivar-specific resistance or susceptibility. Root exudates derived from susceptible banana cultivars, Rasthali and Red Banana, significantly enhanced Foc spore germination and chemotactic response compared to exudates obtained from Foc Race 1 resistant cultivars, Rose and Grand Naine. This differential response suggests that exudates from susceptible cultivars may contain specific chemical cues promoting pathogen activation and directional growth, whereas exudates from resistant cultivars either lack such stimulatory signals or contain inhibitory components that suppress pathogen responsiveness.

Were there any specific compounds in the root exudates that surprised you in the way they influenced fungal growth, spore germination, or chemotropism?

The study reveals the complex role of banana root exudates in influencing the behaviour of Foc, particularly in spore germination and chemotropism. Among the organic acids tested, oxalic and malic acids strongly inhibited spore germination at low concentrations (0.5 µM), while phthalic acid required higher levels (5 µM). These effects may result from environmental acidification, membrane disruption, or ion chelation. Despite inhibiting germination, these acids increased chemotropism, suggesting continued fungal attraction. In contrast, cinnamic acid reduced chemotropism in a dose-dependent manner, indicating a signalling interference role A peak corresponding to oxalic acid was observed in Rasthali and Red Banana cultivars, while a smaller peak was detected in Grand Naine. Malic acid was consistently present in Rasthali, Red Banana, and Rose cultivars, indicating its widespread role in root exudate composition. Additionally, fumaric acid was uniquely detected in the Rose cultivar, pointing to possible cultivar-specific metabolites. All three phenolic acids, cinnamic acid, phthalic acid, and salicylic acid were detected across all four cultivars. Overall, these findings suggest that banana cultivars differ in both the composition and concentration of root exudates, which in turn influence Foc behaviour through a combination of attractant signals and inhibitory effects, ultimately shaping the outcome of host-pathogen interactions in the rhizosphere.

Do you think this kind of research could help develop natural or sustainable strategies to manage banana wilt disease in the future?

Understanding these interactions provides critical insight into the mechanisms underlying disease suppression in banana-Foc pathosystem and opens avenues for innovative management strategies. The differential response of Foc to specific root exudate components suggests that host plants actively shape pathogen behaviour through chemical signalling in the rhizosphere. This knowledge can be leveraged to develop resistant cultivars with optimized exudate profiles, or to design targeted microbiome engineering approaches that enhance beneficial microbial communities capable of suppressing pathogen establishment. Additionally, exudate-based interventions could be employed to manipulate the rhizosphere environment in ways that disrupt pathogen recognition and colonization. A particularly promising direction lies in identifying key molecules within root exudates that inadvertently act as signals for Foc recognition, activation, and development which can be strategically targeted using biotechnological tools or inhibitor-based chemical approaches. Eliminating or reducing the production of these signalling compounds may enable the host plant to remain effectively in a 'stealth mode,' avoiding detection by the pathogen even in infested soils. Conversely, if certain exudate compounds exhibit strong inhibitory effects on Foc, they could be exploited as natural fungicidal agents. These molecules may be developed into ready-to-use formulations for field application or, alternatively, their biosynthetic pathways could be enhanced through genetic engineering. Together, such strategies highlight the potential of integrating chemical ecology, plant breeding, and biotechnology to achieve sustainable and targeted control of Fusarium wilt.

What are the next steps, and what still needs to be understood before such findings can be translated into practical disease control approaches?

Comprehensive chemical profiling of banana root exudates across cultivars requires full-spectrum metabolomics to capture diverse metabolites. Comparing resistant and susceptible cultivars can reveal compounds

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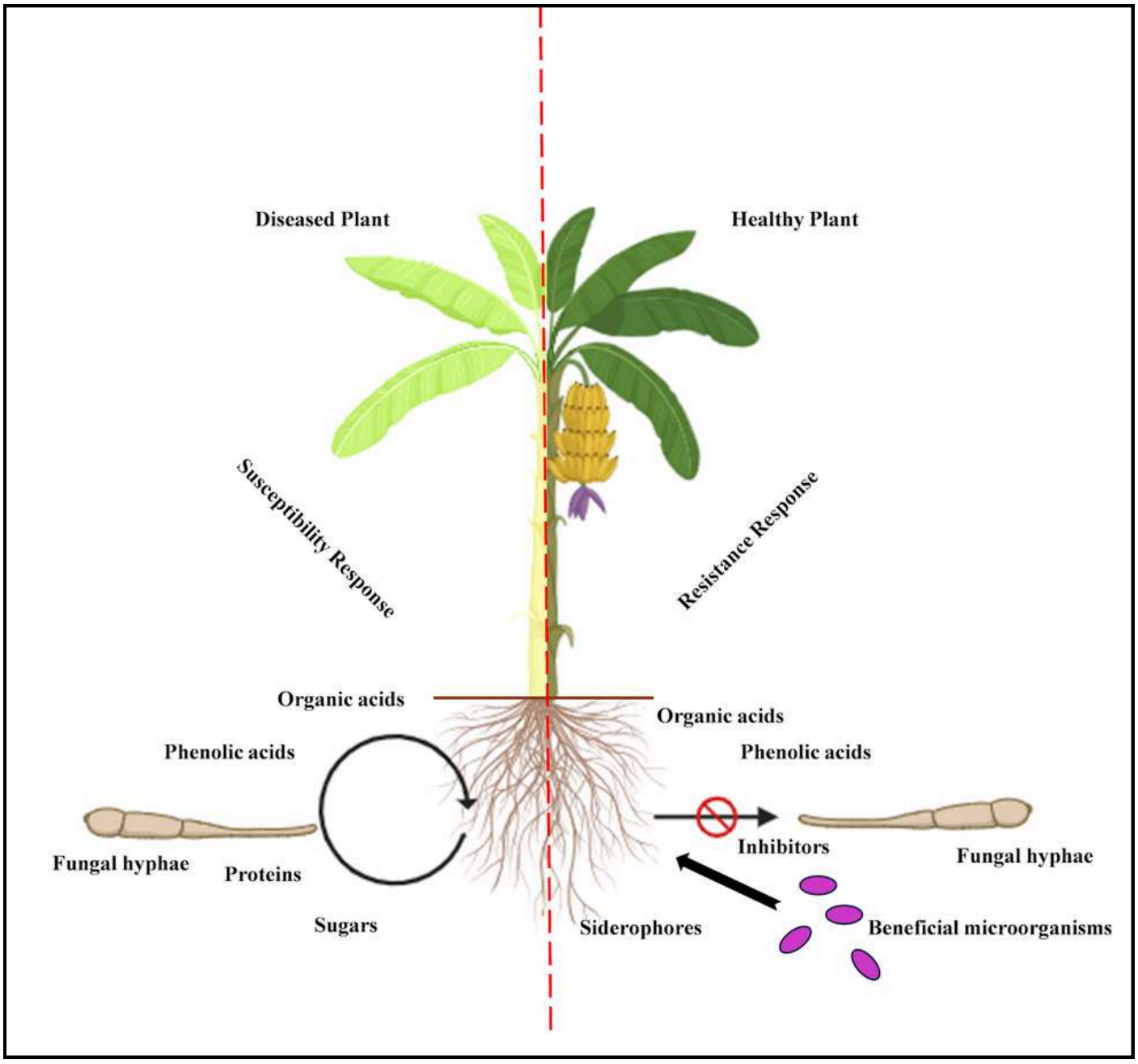
linked to defense or susceptibility, while assessing their thresholds, stability, and persistence in soil is essential. Functional validation must determine whether pathogen recognition relies on a single molecule or a combinatorial chemical fingerprint. This distinction is critical for understanding signaling mechanisms. Insights gained could guide development of soil amendments with synthetic inhibitory compounds. Additionally, studying how exudates shape the soil microbiome may uncover beneficial microbes that suppress pathogens, supporting sustainable, systems-level disease management strategies.

Dr. Ghag's work is reflected in their work published in *Microbial Ecology* (2026).
https://doi.org/10.1007/s00248-025-02693-z



| SCIENCE DESK |

WHEN A SIMPLE MINERAL DEFICIENCY CAUSES SERIOUS SYMPTOMS

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What first led you to investigate this unusual presentation of asterixis in your patient?

The investigation into this patient's unusual presentation of asterixis was driven by several clinical inconsistencies. In a patient with chronic kidney disease (CKD) generally presence of asterixis suggests uremic encephalopathy and requires haemodialysis. But in this case patients eGFR and serum creatinine levels were stable; urine output was maintained and there were no symptoms and evidence of uraemia.

Also, the patient, an elderly woman with type 2 diabetes and hypertension, presented with neurological symptoms including tingling sensation in all four limbs (for 8 months) and muscle cramps (for 1 month). Yet upon examination her neurological findings were normal.

Her electrocardiogram (ECG) showed a significantly prolonged QTc interval of 516 milliseconds which prompted further evaluation.

Can you explain in simple terms what asterixis is and why it is usually linked to more severe conditions?

In simple terms, asterixis is a movement disorder characterized by an inability to maintain a fixed posture due to involuntary interruption in muscle contraction. It is often referred to as a "flapping tremor" because it looks like a bird flapping its wings when a patient tries to hold their hands out with the arms extended and wrists dorsiflexed. Technically, it is not a true tremor and it is a form of negative myoclonus. This means that instead of an active shaking, there is a brief, sudden loss of muscle tone that causes the hand to drop momentarily before the brain quickly corrects the position.

Asterixis typically signifies a significant disruption in the brain's ability to regulate motor control and are therefore are linked to more severe conditions that interfere with the central nervous system's signalling like -

-Organ failure associated metabolic encephalopathies including liver failure, kidney failure and respiratory failure

-Structural brain damage to specific areas of the brain, such as the thalamus or midbrain, which are responsible for coordinating movement and posture.

- Severe Electrolyte imbalances such as hypomagnesemia identified in this case, can disrupt the electrical stability required for normal muscle tone and posture.

What made this case different, and how did you identify hypomagnesemia as the underlying cause?

The patient an elderly woman with type 2 diabetes, diabetic nephropathy and hypertension had neurological manifestations and bilateral asterixis. What made this case different was a stable renal profile without uraemia and normal neurological examination and imaging.

Her liver function test and standard serum electrolyte panel was normal and no history of drugs causing asterixis was found.

Her ECG showed a prolonged QTc interval of 516 milliseconds, prompting evaluation of serum calcium and magnesium levels. The results revealed a serum calcium of 10 mg/dL (corrected calcium was 10.32 mg/dL) and a serum magnesium of 1.1 mg/dL which was reduced.

As hypomagnesemia is induced by two major mechanisms: gastrointestinal or renal losses, she underwent further evaluation for the underlying cause. The underlying cause of the depletion was ultimately attributed to diabetes mellitus–related renal magnesium wasting, as her 24-hour urinary magnesium was significantly elevated and other renal causes of hypomagnesemia were ruled out.

The diagnosis was also confirmed when the patient's asterixis resolved completely following magnesium supplementation.

What surprised you the most during this diagnostic process?

Magnesium deficiency usually occurs as part of a complex electrolyte imbalance involving low potassium or calcium. In this case, the patient's potassium and calcium levels were completely normal making it a case of Isolated magnesium deficiency, which is rare.

It was striking to find that her diabetes was the primary cause of such severe magnesium wasting. Despite the body being deficient, her kidneys continued to lose magnesium at a high rate (157 mg/24 hours), highlighting how

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diabetes can actively disrupt mineral homeostasis.

Another rewarding surprise was the complete resolution of the flapping tremors once the magnesium was replaced, confirming that a seemingly complex neurological presentation could be fixed with a straightforward metabolic correction.

Why is magnesium deficiency often overlooked, especially in patients with diabetes?

The prevalence of hypomagnesemia is approximately 2% in the healthy population while in Type 2 diabetes, it is between 9.1% and 47.7%. Henceforth, hypomagnesemia occurs about ten times more frequently in diabetics than in the general population.

Magnesium deficiency is frequently overlooked in clinical practice, particularly in patients with diabetes, for several reasons:

Magnesium is not typically included in a standard, routine electrolyte panel, meaning it is often not measured unless a clinician specifically orders it.

Neurological symptoms of hypomagnesemia, such as paraesthesia like tingling and muscle cramps, can be assumed to be due to diabetic peripheral neuropathy. Lack of specific symptoms or physical signs that point exclusively to hypomagnesemia makes it harder to identify.

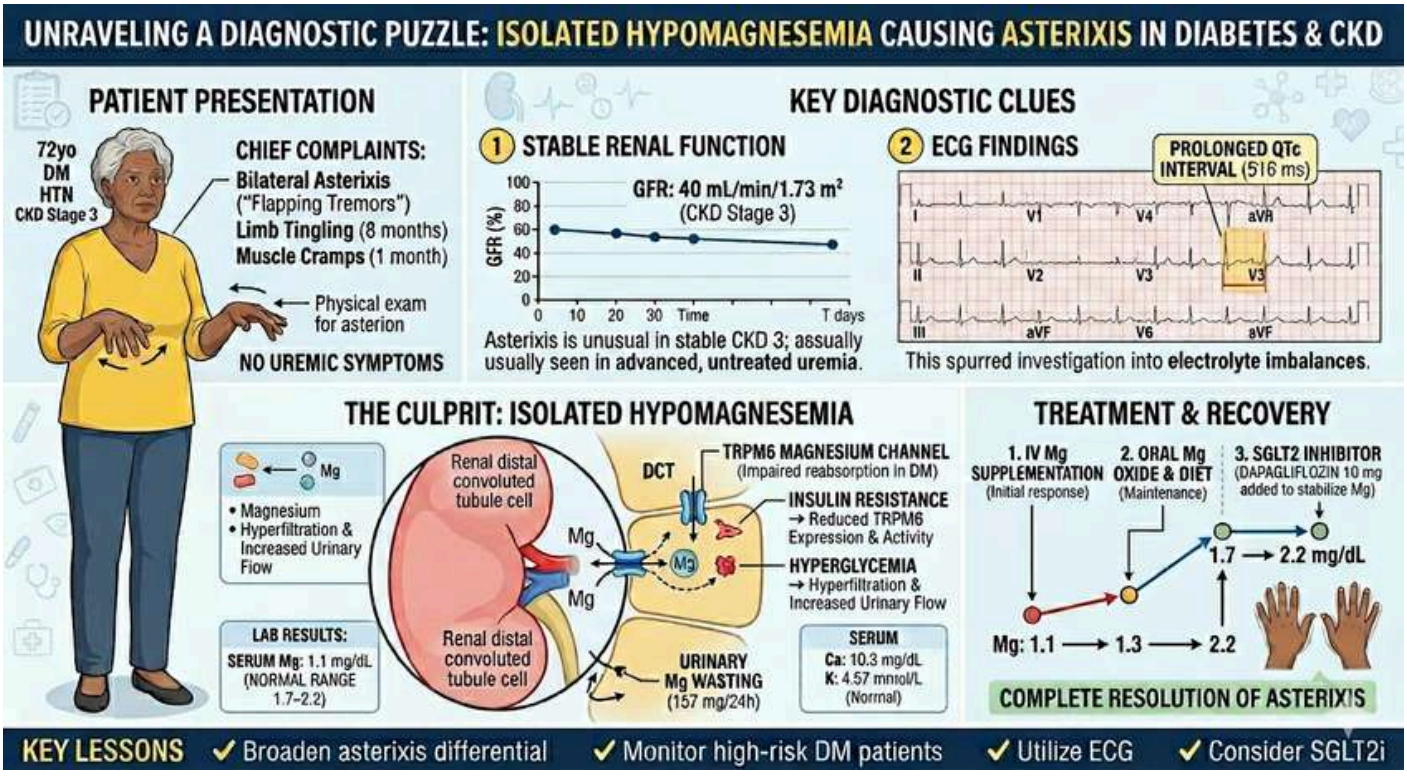
There is currently a lack of organized consensus guidelines to help clinicians screen and manage for hypomagnesemia systematically.

What are the key lessons for clinicians and what further research is needed in this area?

This case highlights the importance of evaluating for underlying causes of asterixis, as well as the predisposition of individuals with diabetes mellitus to renal magnesium wasting. Hypomagnesemia, although frequently overlooked, is a clinically important electrolyte disturbance that can present with diverse neurological, cardiovascular, endocrinal and muscular manifestations. Identifying this condition presents a significant diagnostic challenge, yet it offers the potential for a complete clinical recovery. Consequently, early recognition and prompt correction are essential to achieving a positive outcome and preventing further complications.

Further research is needed in this area as there is currently limited data and a lack of organized consensus guidelines to guide clinicians on how to systematically screen for and manage hypomagnesemia.

Dr. Pahwa's contribution to this field is reflected in their work published in *BMC Geriatrics* (2026). DOI: 10.1186/s12877-026-07281-5



| SCIENCE DESK |

THE STORY BEHIND A NEW BACTERIAL DISCOVERY

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Areas of Expertise: Chemical Biology | Nano-Omics

What first led you to study bacteria in silkworms, and how did this discovery begin?

India is one of the world's leading producers of silk, and sericulture is a crucial agro-based industry supporting millions of rural livelihoods, particularly in states such as West Bengal, Karnataka, Assam, and Tamil Nadu. Our interest in studying bacteria in silkworms originated from the frequent occurrence of bacterial diseases in rearing systems, which significantly affect sericulture productivity in India. Silkworms are highly sensitive to microbial infections, often acquired through contaminated mulberry leaves or rearing environments conditions commonly observed in traditional rearing practices. During routine screening of diseased larvae, we isolated an unusual bacterial strain from the silkworm gut. What initially appeared to be a typical infection gradually revealed distinct biological and genetic characteristics, prompting further investigation. In the Indian context, such findings are particularly important, as understanding novel bacterial associations can contribute to improved disease management strategies, enhanced rearing practices, and ultimately better silk yield and quality, thereby strengthening the sustainability of the sericulture sector.

Can you explain in simple terms what makes this bacterium new and different from others?

This bacterium is considered "new" because it shows clear differences from known species at both genetic and physiological levels. Its genome, biochemical behaviour, and growth characteristics do not fully match any previously described bacteria. In simple terms, it belongs to a known group but behaves differently enough like having a unique genetic "fingerprint" that it qualifies as a new species.

Your study mentions that this bacterium is drug-resistant, why is that important for science and society?

Drug resistance means that the bacterium can survive exposure to antibiotics that would normally kill it, and this phenomenon is fundamentally a question of molecular interactions and biochemical adaptation. Antibiotics function by targeting specific cellular components such as cell wall synthesis, protein translation, or DNA replication but drug-resistant bacteria evolve chemical strategies to evade or neutralize these effects. These may include enzymatic degradation of the drug, structural modification of antibiotic targets, altered membrane permeability, or the active efflux of antibiotics through transport proteins.

I view drug resistance as a dynamic interplay of small molecules, enzymes, and metabolic networks within the microbial system. Studying such bacteria allows us to dissect the exact chemical mechanisms underlying resistance for example, identifying resistance-conferring enzymes, characterizing metabolic shifts, or mapping interaction pathways between antibiotics and cellular targets. This insight is critical for rational drug design, enabling the development of next-generation antibiotics that can bypass resistance mechanisms or inhibit them directly.

Beyond medicine, this has broader implications for agriculture and sericulture, where resistant microbes can compromise animal health and productivity. By understanding resistance at the molecular level, we can design targeted antimicrobial compounds, develop biosensors for early detection, and create sustainable intervention strategies that minimize the emergence and spread of resistance. Thus, investigating drug-resistant bacteria is not only about combating infections but also about decoding and manipulating the chemical language of life to address one of the most pressing challenges facing science and society today.

What surprised you the most during this research or discovery process?

One of the most surprising findings was how this bacterium could persist and adapt within the silkworm gut environment while simultaneously carrying multiple drug-resistance traits. This was particularly striking because the silkworm gut, though seemingly simple, represents a highly dynamic chemical microenvironment shaped by host metabolism, dietary inputs (mulberry leaves), and microbial interactions. The bacterium's ability to survive here suggests that it is not merely passively existing, but actively modulating its biochemical pathways adjusting metabolite production, regulating stress-response molecul-

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es, and possibly altering membrane chemistry to withstand both host defenses and antimicrobial pressures.

What stood out most was the sophistication of its survival strategies at the molecular level. The coexistence of multiple resistance traits implies coordinated chemical mechanisms, such as enzyme-mediated drug modification, efflux pump activation, and metabolic flexibility that allows the bacterium to thrive under fluctuating conditions. This level of adaptability in a niche insect gut environment challenges the conventional assumption that complex resistance evolution is restricted to clinical or heavily antibiotic-exposed settings.

This discovery highlights that even micro-scale ecosystems like the silkworm gut can function as active reservoirs and evolution hubs for chemically driven resistance mechanisms. It underscores the importance of exploring such underappreciated environments to uncover hidden biochemical diversity and resistance pathways. These insights not only deepen our understanding of microbial chemical ecology but also have significant implications for predicting resistance emergence, guiding antimicrobial design, and developing more informed strategies for both biomedical and agricultural disease management.

Do you think this bacterium could have any impact on human health, agriculture, or the environment?

Yes, potentially. Such bacteria can have significant impacts across agriculture, human health, and the environment. In agriculture, particularly in sericulture, the presence of drug-resistant bacteria in silkworms can lead to persistent infections that are difficult to control, thereby reducing cocoon yield and affecting farmer livelihoods.

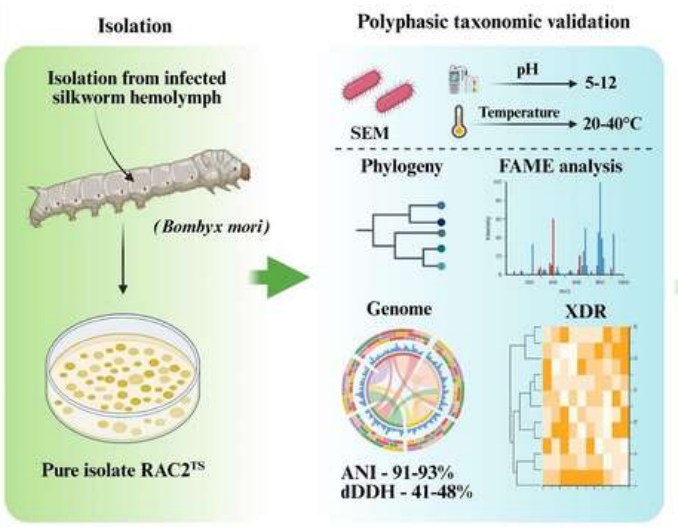
From a broader chemical and ecological standpoint, these bacteria are important because they can act as reservoirs of resistance genes embedded within mobile genetic elements and biochemical pathways. Such resistance traits can spread across microbial communities through processes like horizontal gene transfer, potentially reaching human-associated pathogens which is an interconnected system driven by molecular interactions and chemical adaptation across ecosystems. Understanding how these resistance mechanisms originate, evolve, and transfer is essential not only for improving disease management in sericulture but also for predicting and mitigating the spread of antimicrobial resistance, making these bacteria highly relevant from both ecological and global public health perspectives.

What are the next steps that still need to be studied before we fully understand this bacterium?

Several important questions remain before we can fully understand this bacterium and its broader implications. First, it is essential to decipher the precise molecular and biochemical mechanisms underlying its drug resistance, including the specific genes, enzymes, and metabolic pathways involved. Second, its direct role in silkworm disease progression needs to be clearly established whether it acts as a primary pathogen, an opportunistic invader, or part of a more complex disease network. Third, understanding its interactions within the host microbiome is critical, as these microbial relationships may influence both its survival and pathogenic potential. Finally, it is important to assess any potential cross-species transmission or environmental risk, particularly in the context of resistance gene dissemination.

Future research should integrate functional genomics, metabolomic profiling, controlled infection models, and ecological tracking to map how this bacterium operates at the molecular level and within real-world systems. Such studies will be crucial for building a comprehensive understanding of its biology, evolution, and impact across agricultural and environmental contexts.

Dr. Mondal's contribution to this field is reflected in their work published in *Systematic and Applied Microbiology* (2026) 10.1016/j.syapm.2026.126699



Discovery of *Stenotrophomonas raiganjensis* sp. nov.

| SCIENCE DESK |

THE STORY BEHIND TURNING PLASTIC WASTE INTO A SMART WOUND-HEALING MATERIAL

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Areas of Expertise: Biopolymer | Tissue Engineering | Noviral Gene Therapy

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Areas of Expertise: Polymer Synthesis | Tissue Engineering

What first inspired you to explore PET plastic waste as a source for developing biomedical materials, and how did this research begin?

The inspiration for this work arose from addressing two major global challenges: the growing accumulation of plastic waste and the need for advanced, affordable biomedical materials. As a researcher in polymeric biomaterials, I have always aimed to develop functional systems that directly benefit human health. At the same time, the environmental impact of non-biodegradable plastics like PET, which persist for decades, prompted us to rethink waste as a resource rather than a problem.

Our approach began with chemical recycling of PET through glycolysis, producing bis(2-hydroxyethyl) terephthalate (BHET). Interestingly, BHET closely resembles organic linkers used in metal–organic frameworks (MOFs), which led us to explore its potential in constructing functional materials. This marked the starting point of our research.

We then developed a copper-based BHET MOF, leveraging the inherent antimicrobial properties of copper. The breakthrough came with the integration of graphene oxide, which significantly enhanced biological performance due to its unique surface and antibacterial characteristics.

Ultimately, this work reflects a simple yet impactful idea: transforming plastic waste into a high-value biomedical material. It represents our broader vision of merging sustainability with advanced materials science to create solutions for both environmental and healthcare challenges.

Can you explain in simple terms how discarded plastic bottles were converted into a useful wound-healing material?

At first glance, a discarded plastic bottle and a wound-healing material may seem unrelated, but chemistry allows us to bridge this gap. We began with used PET plastic bottles, which were cleaned, cut into small pieces, and subjected to a recycling process called glycolysis. This process breaks the long plastic chains into smaller molecules, producing a key compound known as bis(2-hydroxyethyl) terephthalate (BHET).

BHET serves as a building block for advanced materials called metal–organic frameworks (MOFs). By combining BHET with copper ions, we created a porous, highly structured material. This structure is important because it provides a large surface area, enabling effective interaction with biological systems. Copper further contributes by offering natural antibacterial properties, helping to prevent infection.

To enhance performance, we incorporated graphene oxide, a carbon-based nanomaterial known for improving cell interaction and antibacterial activity. The resulting composite material can reduce oxidative stress, inhibit bacterial growth, and promote cell regeneration.

In simple terms, we transformed plastic waste into a smart material that supports faster wound healing. This approach not only helps manage plastic pollution but also advances the development of innovative and functional healthcare materials

Your study combines sustainability with healthcare—why is this kind of waste-to-biomedicine approach important for science and society?

Integrating sustainability with healthcare offers a powerful solution to two major global challenges: plastic pollution and the need for advanced, affordable medical materials. PET waste, which accumulates in massive quantities and persists for decades, poses a serious environmental threat. At the same time, healthcare systems require materials that are not only effective but also safe, scalable, and cost-efficient. A waste-to-biomedicine approach connects these needs by transforming environmental waste into valuable

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biomedical resources.

From a scientific perspective, this strategy encourages innovation by treating waste as a chemical feedstock rather than a disposal problem. Converting PET into functional materials such as metal–organic frameworks enables the design of bioactive systems with antibacterial, antioxidant, and tissue-compatible properties. This expands the scope of materials science while supporting circular economy principles.

From a societal standpoint, such approaches can lower the cost of healthcare by reducing dependence on expensive raw materials. This is particularly beneficial in resource-limited settings, where affordable wound care solutions are crucial. At the same time, it helps reduce plastic accumulation and promotes high-value recycling.

Overall, waste-to-biomedicine represents a paradigm shift, demonstrating that environmental sustainability and healthcare innovation can work together to create meaningful impact.

What surprised you the most during the development or testing of the GO@Cu-BHET MOF material?

What surprised us most was the extent to which graphene oxide enhanced the overall performance, even at very low concentrations. While some improvement was expected due to its known properties, the magnitude of enhancement—particularly in biological activity—was far beyond our initial expectations.

The most striking result came from the wound healing assay, where GO@Cu-BHET MOF achieved nearly complete wound closure within 24 hours at just 10 µg/mL. In contrast, the Cu-BHET MOF without graphene oxide showed only partial healing under the same conditions. This highlighted a strong synergistic interaction between graphene oxide and the copper-based framework.

We also observed a significant boost in antioxidant activity. While Cu-BHET MOF showed moderate scavenging, the GO-integrated system reached around 80% activity at higher concentrations, indicating a more active role of graphene oxide in radical neutralization.

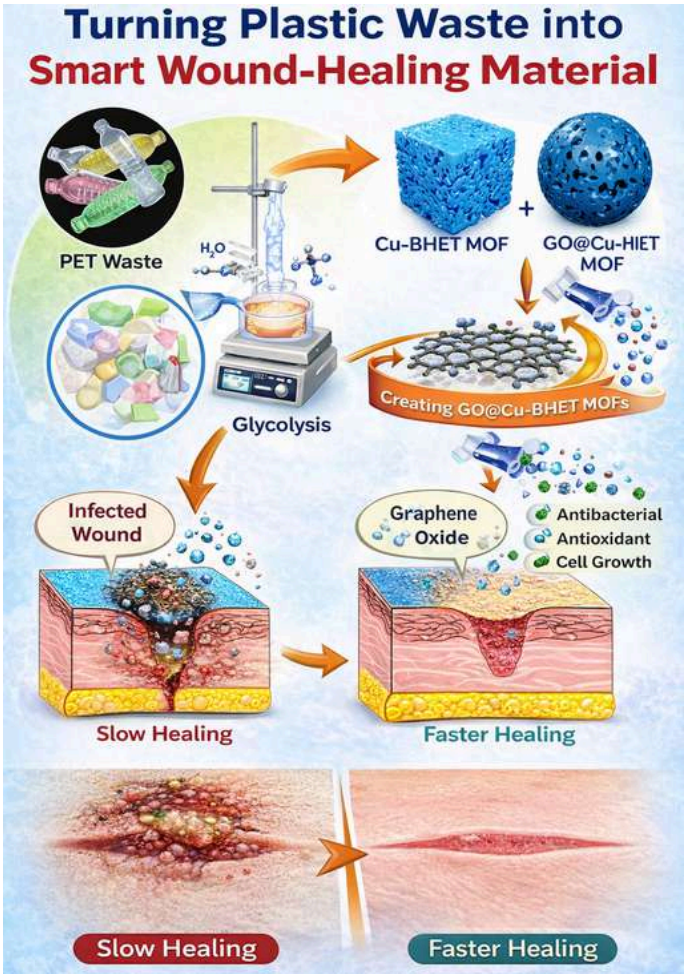
Importantly, these enhancements did not compromise cytocompatibility, with both materials maintaining over 90% cell viability. Overall, the synergy between components was the most unexpected and impactful finding of this study.

Do you think this material could have broader applications in wound care, infection control, or other biomedical fields?

Yes, we believe this material has strong potential beyond wound healing. The GO@Cu-BHET MOF combines key properties such as antioxidant activity, antibacterial performance, and cytocompatibility, making it suitable for a wide range of biomedical applications.

In wound care, it can be developed into advanced formats like hydrogels, coatings, or dressings that provide sustained antibacterial protection while promoting tissue regeneration. Its ability to achieve rapid healing at low concentrations makes it particularly promising for chronic wounds, burns, and diabetic ulcers.

From an infection control perspective, the material could be used as an antimicrobial coating on medical devices and implants. The combination of controlled copper ion release and graphene oxide-induced membrane disruption offers a dual mechanism to prevent bacterial growth and biofilm formation.



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Additionally, its porous structure enables drug loading and controlled release, making it useful for drug delivery and tissue engineering applications. Overall, its multifunctional and tunable nature makes it a versatile platform for next-generation biomedical technologies.

What are the next steps, and what still needs to be studied before this material can move closer to real-world medical use?

While our findings are encouraging, several steps are needed before this material can be translated into real-world medical use. The immediate priority is to evaluate its performance in in vivo wound healing models, which will help confirm its efficacy, safety, and behaviour under physiological conditions. These studies will also provide insights into immune responses and tissue regeneration processes.

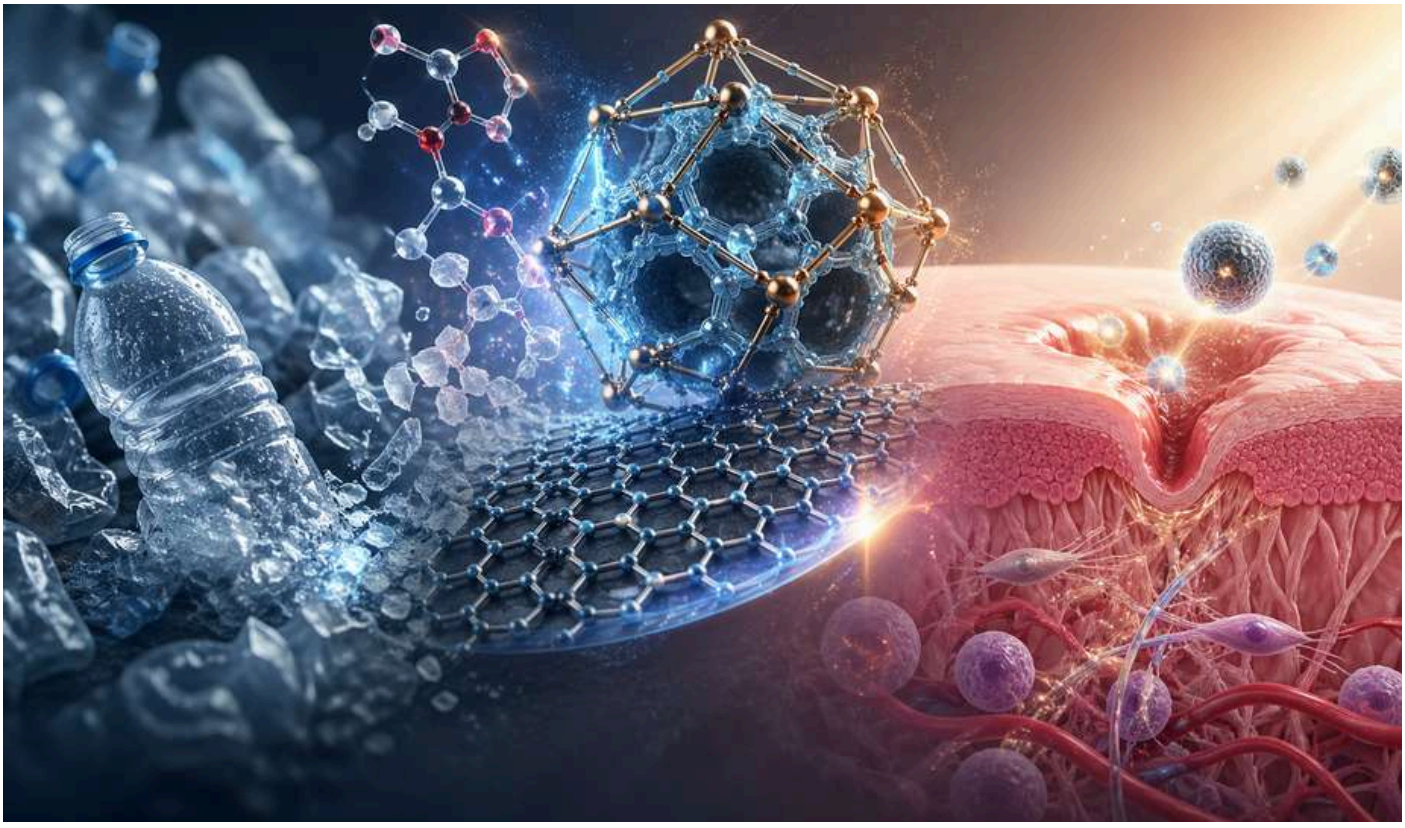
Another key requirement is assessing long-term biocompatibility and toxicity. Although in vitro results showed excellent cell viability, it is essential to study biodegradation, clearance, and the long-term effects of copper ion release to ensure safety.

We also aim to develop practical formulations, such as incorporating the material into hydrogels, films, or nanofiber dressings. Factors like stability, sterilization, and shelf-life must be optimized for clinical application.

From a translational perspective, ensuring scalable and reproducible synthesis is critical, especially when using PET waste as a starting material. Consistency in raw material quality must be maintained.

Finally, regulatory approval will require comprehensive evaluation of safety, efficacy, and comparison with existing treatments. Overall, advancing this material toward clinical use will require coordinated efforts across materials science, biology, and medicine.

Dr. Sarkar and Ms. Ghosh work is reflected in their work published in *Colloids and Surfaces B: Biointerfaces* (2026) 10.1016/j.colsurfb.2026.115588



| SCIENCE DESK |

HOW CELLS CHANGE AND SPREAD BEYOND THE UTERUS

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| Organization Link |
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Areas of Expertise: Stem Cell Biology | Nano-Omics Epigenetic Regulation | Cell Signaling Pathways | Regenerative Medicine

What first inspired you to investigate the molecular biology of endometriosis, and how did this research begin?

When I joined Symbiosis Centre for Stem Cell Research (SCSCR) in 2019, we wanted to study a gynecological disorder common in India but poorly understood. While many researchers study endometriosis, few focus on its epigenetic mechanisms. I noticed no one had explored the role of Polycomb repressive complex 1 in Epithelial to Mesenchymal Transition (EMT) gene regulation, so we began pilot experiments and later secured funding to pursue this. I did some pilot experiments to see if we can culture cells from endometrial biopsy as well as extract RNA and protein for molecular biology assays. We first wrote up a research proposal and submitted it to funding agency, and when the proposal was approved for funding we began work in 2024.

Can you explain in simple terms what endometriosis is and why understanding cell behavior is important in this condition?

Endometriosis is a complex disease since many researchers now believe that this disease may not be just one disease but could be 3 to 4 sub conditions, like how in early 20th century mental illness could mean depression, hysteria, bi polar disorder, schizophrenia, dementia. So far what we can say confidently about endometriosis is that it a condition that primarily affects women of reproductive age, where small bits of endometrial tissue are found outside the uterus such as ovary. Once at these sites outside uterus , the tissue leads to painful periods, painful intercourse and heavy menstrual bleeding, and may possibly lead to infertility. Thus, one of the critical aspects of endometriosis is migration of endometrial cells towards other sites and understanding it might help us in treating endometriosis.

Your study links Polycomb proteins with EMT-related genes why is this finding important for understanding endometriosis and women's health?

Worldwide there are millions of women suffer from endometriosis, but unfortunately there is no definitive cure for this condition. Our study showed that EMT gene are active in the ectopic tissue (endometrial tissue found in lesions away from the endometrium), and we showed correlation between Polycomb group (PcG) proteins and EMT genes. If future studies confirm this correlation, then the PcG proteins could serve as potential targets for synthetic compounds that are already being used in several clinical trials for treating several types of cancers.

What surprised you the most during your research or while comparing eutopic and ectopic tissues?

When we compared the ectopic and eutopic tissue we were surprised to see the differences, I assumed there would be only minor differences, but there were major differences in expression of genes such as - crystallin gamma D (CRYGD), Follicle stimulating hormone receptor (FSHR), Diencephalon/mesencephalon homeobox 1 (DMBX1), IZUMO1R Aristaless-related homeobox (ARX1) and Leptin (LEP) to name a few. Some of these are not know to be required for endometrium but are associated with other tissues such as eyes, brain and fat cells. We also were taken by surprise when results for some markers were completely opposite in transcriptomic data and the Western blot data, especially for RING1B protein. The results showed that we have more to understand about how endometrium carries out its functions as well we have lot to discover about protein and mRNA stability inside living cells. Another surprising aspects was the lack of data regarding the number of patients diagnosed with endometriosis in India, we only have estimate but no empirical data.

Do you think these findings could eventually help in improving diagnosis, treatment, or awareness of endometriosis?

I get asked this question often, and my aim when I started work was to find out whether Polycomb group (PcG) proteins regulate EMT in endometrium and whether this regulation fails in endometriotic tissue. Now, that we have shown some correlation, we want to confirm if EMT genes are truly regulated by the Polycomb group (PcG) proteins.

| SCIENCE DESK |

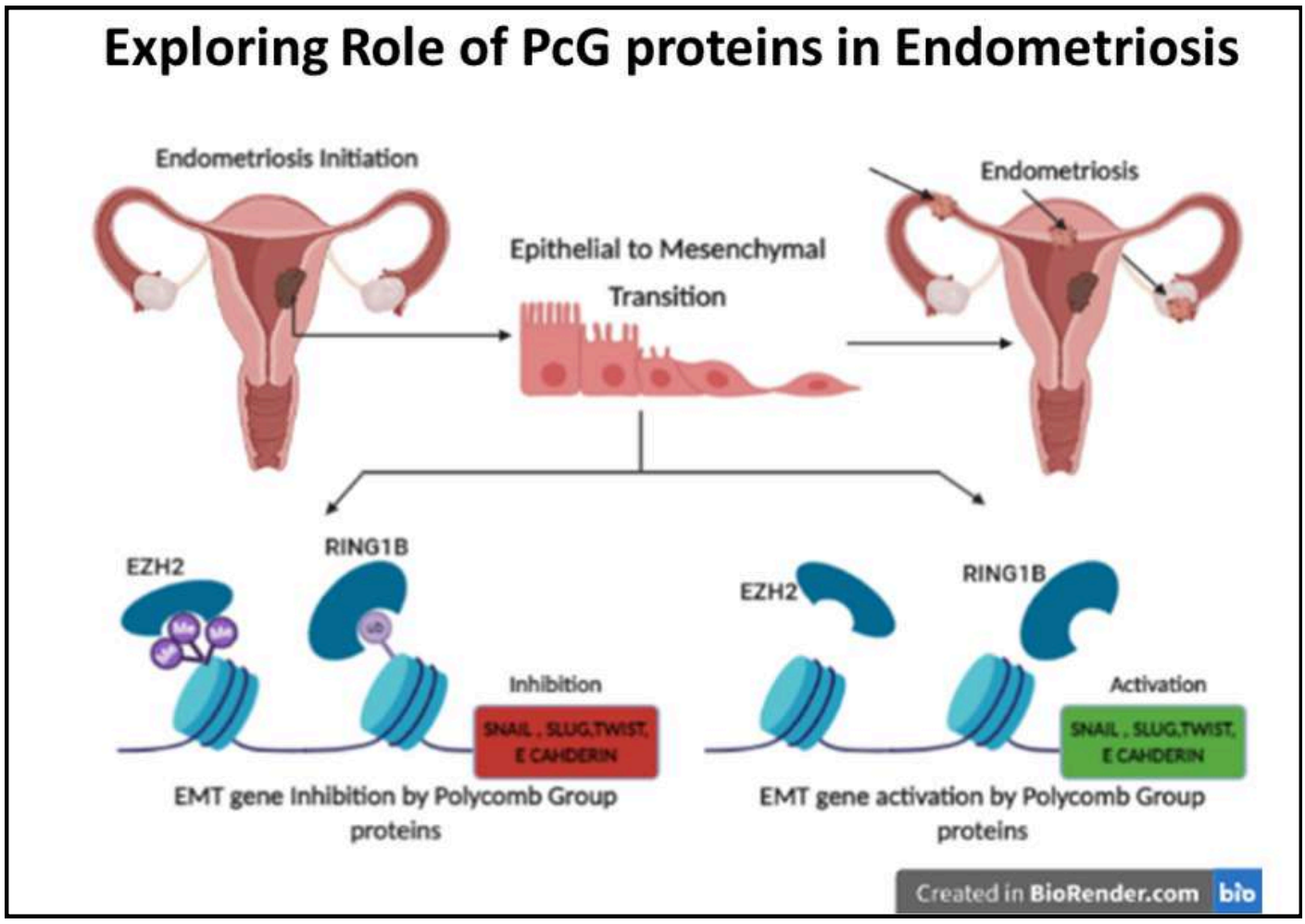
HOW CELLS CHANGE AND SPREAD BEYOND THE UTERUS

If we can show that, then the findings may have implications in treatment of endometriosis, since there are several FDA approved small molecules that can inhibit Polycomb group (PcG) proteins and these could be repurposed for endometriosis treatment.

What are the next steps, and what still needs to be understood before we fully uncover the molecular causes of endometriosis?

We plan to use chromatin immunoprecipitation qPCR or Chromatin immunoprecipitation sequence to assess if the Polycomb group (PcG) proteins such as RING1B, EZH1 and BMI1 can bind to promoter of key EMT and endometrial genes to regulate their gene expression. We plan to also deplete the endometrial cells of Polycomb group (PcG) proteins to assess if it affect the proliferation of these cells. By doing these experiments we would be able to add more to the literature on the molecular mechanisms involved in endometriosis.

Dr. Pethe's work is reflected in their work published in Reproductive Biology (2026). 10.1016/j.repbio.2025.101173



| SCIENCE DESK |

THE STORY BEHIND A SMART NANOBIOHYBRID: WHERE PROBIOTICS MEET NANOTECHNOLOGY

Dr. Abhinandan Patil
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| Scientific Profile |
| Organization Link |
| Factors Press |
Areas of Expertise: Probiotic therapeutics & nanobiohybrids | Antimicrobial strategies | Cancer biology & oxidative stress | Nutraceuticals

What inspired you to combine probiotics with nanoparticles, and how did this research idea begin?

For thousands of years, Indian households have used curd, buttermilk, and fermented foods not just for taste, but for health. Our ancestors knew that friendly bacteria (probiotics) keep the gut healthy and the body strong. My own research began with a simple question: Can we make these friendly bacteria even more powerful using modern science?

I have spent over a decade studying Lactobacillus strains the same family of bacteria found in yogurt. I discovered two new strains from sheep milk, deposited them in India's National Centre for Microbial Resource, and even helped develop a probiotic biscuit that reached the Indian market. But I wanted to go further.

At the same time, scientists around the world were exploring nanoparticles particles so small that thousands could fit on a single hair. Iron-based nanoparticles are known to kill harmful bacteria, but they can also be toxic to our own cells.

Then came the "eureka" moment: What if we coat the probiotic with nanoparticles? The probiotic would act as a living, protective base. The nanoparticles would add extra killing power. Together, they might be stronger, safer, and smarter than either alone.

That is how the nanobiohybrid was born not in a distant Western lab, but right here in Kolhapur, India, combining ancient wisdom with 21st-century nanotechnology.

Can you explain in simple terms what a nanobiohybrid is and how it works?

Imagine a friendly soldier a probiotic bacterium that already knows how to fight bad germs. Now imagine giving that soldier a special armor made of ultra-tiny magnetic particles (maghemite, a form of iron oxide). That armored soldier is a nanobiohybrid. Here is how it works in simple steps: Component Role Probiotic (Lactobacillus rhamnosus) Lowers pH, secretes natural antibacterial chemicals, and is already safe for humans. write inparagraphs withut chsniung many words Maghemite nanoparticles (γ-Fe_2O_3) Generate reactive oxygen species think of them as "oxidation bombs" that destroy bacteria and break down sticky biofilms Nanobiohybrid (both together) The probiotic guides the nanoparticles; the nanoparticles boost the probiotic. Together, they kill more bacteria, break more biofilms, and scavenge harmful free radicals The two components are held together by electro-static forces like opposite sides of a magnet. We simply mix them in water, and they self-assemble. No harsh chemicals. No complex machinery. Simple, elegant, and effective.

Your study shows improved antibacterial and antibiofilm activity. Why is this important for real-world problems like infections and wound healing?

Most people think bacteria float around freely. In reality, most harmful bacteria stick to surfaces medical implants, catheters, wounds, teeth, even kitchen counters and form a slimy, protective layer called a biofilm. You can think of a biofilm as a fortress. Inside that fortress, bacteria can become up to 1,000 times more resistant to antibiotics. This explains why chronic wounds often do not heal, why urinary catheters can lead to repeated infections, and why some infections seem extremely difficult to treat. Our nanobiohybrid tackles this problem in two important ways. First, it prevents biofilm formation, stopping bacteria from building the “fortress” in the first place. Second, it can eradicate existing biofilms, breaking down the structure even after it has already formed. In our tests, the nanobiohybrid was especially effective against Listeria monocytogenes, a dangerous foodborne pathogen, and Staphylococcus succinus, a known biofilm-forming bacterium. At the highest concentration, it reduced biofilm formation by nearly 80%. This has important real-world implications. Chronic wounds, such as diabetic ulcers, often fail to heal because of persistent biofilms; a spray or gel containing this nanobiohybrid could improve treatment outcomes. Medical devices like catheters, stents, and implants could be coated with it to prevent infections without relying heavily on antibiotics. In food safety, the nanobiohybrid could be incorporated into packaging to limit pathogen growth. Finally, because it works through multiple mechanisms rather than a single pathway, bacteria

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THE STORY BEHIND A SMART NANOBIOHYBRID: WHERE PROBIOTICS MEET NANOTECHNOLOGY

are less likely to develop resistance, making it a promising strategy in the fight against antibiotic resistance.

What was the most surprising or exciting result you observed during your research?

Three results genuinely surprised and excited us.

First, the nanobiohybrid was much safer than nanoparticles alone. When we tested the nanoparticles by themselves on human intestinal (Caco-2) cells, cell viability dropped to about 62% at the highest concentration. However, when combined with the probiotic to form the nanobiohybrid, cell viability remained above 86%. The probiotic essentially acted like a protective cloak, shielding human cells from the harsher effects of the nanoparticles. Second, the probiotic did not die in fact, it became stronger. We initially expected that coating the bacteria might reduce their survival. Instead, Lactobacillus remained fully alive. Even more interesting, the coated probiotic showed improved tolerance to stomach acid and bile, suggesting it could survive longer if administered orally.Third, the hybrid was able to break down mature biofilms, not just prevent them. Many studies focus only on preventing biofilm formation, which is like checking whether a lock can stop a thief from entering. But what happens if the thief is already inside? We addressed both scenarios. The nanobiohybrid not only prevented biofilms from forming but also disrupted already established ones reducing them by nearly 70% in some cases.

These results told us: This is not just another lab curiosity. This could become a real product.

Do you think this nanobiohybrid approach could have future applications in medicine, healthcare, or industry?

Absolutely. I see at least five major application areas for this technology.

One important area is healthcare, especially in treating chronic wounds such as diabetic ulcers. Because biofilms often prevent healing, a nanobiohybrid-based spray or gel could help clear infections and promote faster recovery.

Another key application is in medical devices. Catheters, stents, and implants are highly prone to biofilm-related infections. Coating these surfaces with the nanobiohybrid could significantly reduce infection risk without relying heavily on antibiotics. Food safety is also a promising field. The nanobiohybrid could be incorporated into food packaging materials to prevent the growth of harmful pathogens like Listeria, helping to extend shelf life and improve safety. A fourth area is gut health and probiotic therapy. Since the coated probiotic shows improved tolerance to stomach acid and bile, it could be developed into advanced probiotic formulations that survive longer and function more effectively inside the body.

Finally, this approach could contribute to combating antibiotic resistance. Because the nanobiohybrid works through multiple mechanisms both biological and chemical it becomes much harder for bacteria to develop resistance compared to traditional antibiotics.A word of realism is important. Before any of these applications become real products, we need to complete animal studies followed by human clinical trials. Regulatory pathways for nanobiohybrids are still not clearly defined, as they do not

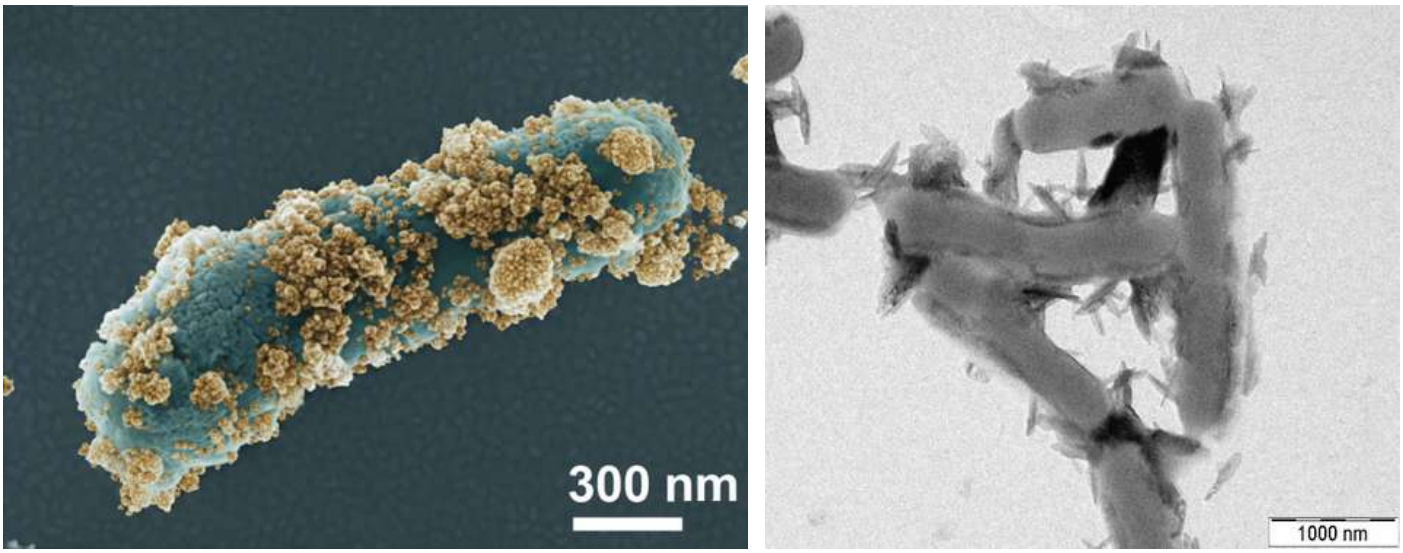

Image of Probiotics and Probiotics coated with Nano-particle (graphically generated image to know the concept in simple way)

| SCIENCE DESK |

THE STORY BEHIND A SMART NANOBIOHYBRID: WHERE PROBIOTICS MEET NANOTECHNOLOGY

fit neatly into existing categories like drugs, medical devices, or probiotics. However, this also presents an opportunity countries like India could take the lead in shaping new regulatory frameworks for such innovative hybrid technologies.

What are the next steps in your research, and what challenges still need to be addressed?

Our immediate next step is to move from the lab bench to living systems. So far, we have completed test-tube (in vitro) and cell-culture studies. The next phase involves animal studies to understand whether the nanobiohybrid works effectively inside a living body, how long it remains active, and whether it causes any hidden toxicity over time. We are currently designing experiments using small animal models, particularly mice, focusing on applications in wound healing and gut health. At the same time, several important challenges need to be addressed. One of the biggest is scale-up. While producing small quantities in the lab is manageable, scaling up to industrial levels while keeping the bacteria alive and ensuring uniform attachment of nanoparticles is much more complex. Stability is another concern, as this is a living material that must remain viable during storage, transport, and handling. Regulatory pathways also remain unclear nanobiohybrids do not fit neatly into existing categories such as drugs, medical devices, probiotics, or nanomaterials, both in India and globally. Cost is equally critical; although nanoparticle synthesis is becoming more affordable, the final product must be accessible to ordinary people, not just high-end healthcare settings. Despite these challenges, I remain optimistic. India has a strong heritage of probiotic use, a rapidly growing biotechnology sector, and a government that actively supports innovation and startups. Having received recognition such as the Start-Up Hero of Maharashtra award under the Make in India initiative, I believe that with the right collaborations and partnerships, this research can be translated into a practical product that benefits millions of people.

Dr. Patil's contributions to this field are reflected in his publication in *New Biotechnology* (2026), https://doi.org/10.1016/j.nbt.2026.02.009

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SCIENTIFIC RESEARCH EMPOWERS SOCIAL PROGRESS !

Answers here – don't peek!

Q1

What makes hydrogel electrolytes safer than traditional liquid electrolytes?

A. They are heavier
B. They are solid-like and reduce leakage
C. They produce more heat
D. They require high voltage

Q2

What was the key role of pantoprazole observed in the study?

A. It increased antibiotic activity
B. It destabilized proteins
C. It stabilized protein structure
D. It blocked drug transport

Q3

What is the main advantage of 3D bioprinting in medicine?

A. Faster surgeries
B. Creation of patient-specific tissues
C. Reduced drug cost
D. Increased hospital beds

Q4

What allows nanozymes to mimic enzyme activity?

A. High temperature
B. Electron transfer reactions
C. Large size
D. Color change only

Q5

What condition describes imbalance in gut microbes due to HIV?

A. Mutation
B. Dysbiosis
C. Oxidation
D. Diffusion

Q6

What controls the 24-hour biological rhythm in humans?

A. DNA replication
B. Circadian clock
C. Enzyme activity
D. Blood flow

Q7

Why are dual-targeting drugs important in cancer treatment?

A. They reduce cost only
B. They target multiple pathways at once
C. They cure instantly
D. They increase tumor growth

Q8

What happens when magnons and phonons strongly interact?

A. They disappear
B. They form magnon-polarons
C. They stop vibrating
D. They produce heat only

DISCOVERY HIGHLIGHTS

PLANT BIOLOGY & STRESS PHYSIOLOGY

SMART NUTRIENT STRATEGY BOOSTS PHOSPHORUS UPTAKE IN CROPS

Phosphorus is essential for plant growth, but much of it in soil remains unavailable due to fixation and declining natural reserves. To address this, researchers developed an innovative strategy combining a slow-release phosphorus material, phytate-intercalated layered double hydroxide (LDH), with phytase-producing rhizobacteria (PPRB). This system works synergistically, where LDH gradually releases phosphorus while microbes convert it into plant-available forms. Tested in tomato (Solanum lycopersicum), the approach significantly improved plant growth, phosphorus uptake, and soil phosphorus availability. Treated plants also showed reduced stress, indicated by lower malondialdehyde levels, along with enhanced metabolism reflected in higher protein content and catalase activity. This study highlights a sustainable and efficient alternative to conventional fertilizers, demonstrating how integrating nanomaterials with beneficial microbes can improve nutrient use and support eco-friendly agriculture.

Gogoi R. et al., Journal of Agricultural and Food Chemistry, 2026.

GENETIC INSIGHTS UNLOCK SEEDLESS GRAPE DEVELOPMENT

Seedless grapes are highly preferred worldwide for their taste, texture, and suitability for fresh consumption and processed products like raisins and juices. However, the biological mechanisms behind seedlessness have remained only partially understood. Researchers from Agharkar Research Institute (ARI), Pune, in collaboration with Savitribai Phule Pune University, have uncovered key genetic and developmental factors responsible for this trait. The study, conducted on a seedless mutant derived from the grape cultivar ARI-516, revealed that pollen sterility plays a central role in seedlessness. Microscopic analysis showed abnormal pollen structure, very low viability, and failure of pollen germination. Additionally, female reproductive structures were significantly reduced in size, disrupting fertilization. Advanced transcriptomic and genomic analyses identified downregulation of genes involved in pollen development and hormone signalling, along with insertion–deletion mutations affecting reproductive processes. These findings indicate that seedlessness arises through parthenocarpy, where fruits develop without fertilization. This research provides valuable molecular markers for breeding improved seedless grape varieties with better yield and quality.

Chavan. et al., BMC Plant Biology, 2025.

POLLEN ANALYSIS REVEALS INDIA'S ANCIENT FARMING HISTORY

Understanding the origins of agriculture in India has long been challenging due to the difficulty of distinguishing crop pollen from wild grasses. A new study by scientists at the Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow, has developed a reliable method to decode this history using pollen micro-morphology from the Central Ganga Plain. Researchers analysed 22 cereal and non-cereal grass species using advanced imaging techniques, including light microscopy, confocal microscopy, and electron microscopy. They identified key distinguishing features such as pollen grain size and annulus diameter. The study established a clear biometric threshold: cereal pollen typically exceeds 46 µm in grain size and 9 µm in annulus diameter, while wild grasses fall below these values. This first-of-its-kind, region-specific framework enables accurate identification of cultivated crops in ancient sediments. It provides a powerful tool for reconstructing past agricultural practices, land use changes, and human influence on ecosystems in India's fertile Ganga Plain.

Tripathi S. et al., The Holocene, 2026.

DISCOVERY HIGHLIGHTS

MICROBIOLOGY & PATHOGEN BIOLOGY

DRUG-RESISTANT FUNGAL LINEAGE EMERGES IN INDIAN HOSPITALS

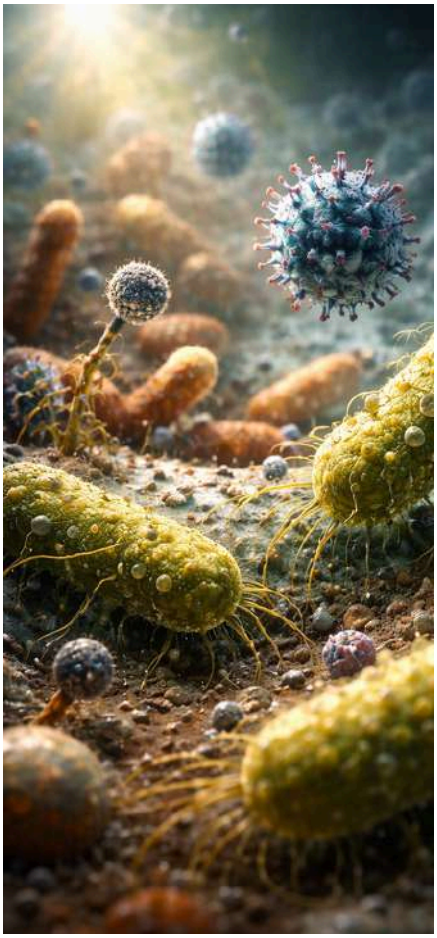
Fungal infections are an increasing global health concern, and Candida tropicalis is a major cause of severe bloodstream infections in the Asia-Pacific region. In a large-scale study, researchers analyzed over 1,000 clinical isolates collected from hospitals across North India over nine years to understand emerging resistance patterns. The study identified a distinct lineage of C. tropicalis showing strong resistance to commonly used azole antifungal drugs such as fluconazole. This resistance was linked to specific genetic changes, including mutations and increased activity of the ERG11 gene, which plays a key role in fungal cell membrane formation. Further analysis revealed that resistant strains also exhibited enhanced virulence traits, including stronger biofilm formation and reduced detection by the human immune system. These features may allow the pathogen to survive longer and spread more effectively in healthcare settings.

Jain K. et al., mBio, 2026.

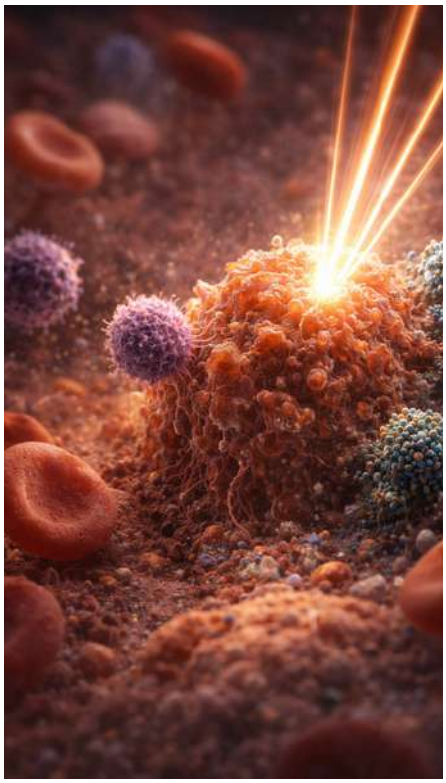
GENE MUTATIONS SIGNAL RISING MALARIA DRUG RESISTANCE RISK

Artemisinin is a key drug used to treat malaria, but resistance to it is becoming a growing concern. In this study, researchers investigated how specific mutations in the kelch13 gene affect drug resistance in Plasmodium falciparum from Bangladesh. Using CRISPR-Cas9, they introduced common global mutations into parasite strains and tested their response to treatment. The results showed that mutations such as C580Y and R561H significantly increased resistance to artemisinin, especially in strains already showing partial resistance. Some mutations also improved parasite survival and growth, making them more likely to spread. This study provides early evidence that malaria parasites in Bangladesh may be genetically prepared to develop strong drug resistance. It highlights the urgent need for continuous monitoring and improved strategies to prevent treatment failure.

Nima M. K. et al., mBio, 2026.



CANCER BIOLOGY & THERAPEUTICS



TARGETED NANOTHERAPY SHOWS PROMISE IN BREAST CANCER TREATMENT

Breast cancer progression is often driven by the overactivity of survival genes that help cancer cells avoid death. In this study, researchers developed a novel nanotechnology-based therapy to selectively silence these genes and suppress tumor growth. The team designed biodegradable, targeted nanocarriers capable of delivering small interfering RNAs (siRNAs) to cancer cells. These nanoconstructs specifically targeted tumor cells and suppressed key survival genes such as MCL-1 and Survivin. When tested in breast cancer models, the treatment successfully induced cancer cell death and led to significant tumor regression in mice. Importantly, the system showed good stability, efficient delivery, and minimal side effects, highlighting its safety. This study demonstrates the potential of

DISCOVERY HIGHLIGHTS

advanced nanomedicine approaches for precise and effective cancer therapy, offering a promising direction for future targeted treatments.
Haldar N. et al., Advanced Healthcare Materials, 2026.

NEW TARGET IDENTIFIED FOR TREATING LEUKEMIA IN DOWN SYNDROME

Children with Down syndrome have a higher risk of developing a specific type of blood cancer called myeloid leukemia. Although many patients respond well to treatment, some cases become resistant, creating a need for better targeted therapies. In this study, researchers identified a key protein called DLK1 as an important driver of this leukemia. They found that DLK1 is activated by a mutated gene (GATA1s) and is highly expressed in cancer cells but not in normal adult blood cells. This makes it an ideal target for therapy. When DLK1 was removed or blocked, cancer cell growth was reduced, and cell death increased. A specially designed antibody-drug treatment targeting DLK1 also showed strong anti-cancer effects and improved survival in experimental models. This discovery highlights DLK1 as a promising new target for developing precise and effective leukemia treatments.
Verboon L. et al., Blood Advances, 2026.

QUANTUM & PHOTONIC MATERIALS

NEW INSIGHTS INTO QUANTUM LIGHT EMISSION IN SILICON MATERIALS

Silicon nitride is an important material used in advanced photonic technologies, especially for developing single-photon sources used in quantum communication and computing. However, the exact origin of its bright quantum light emissions has remained unclear. In this study, researchers used advanced computat-

ional methods to identify the source of these emissions. They found that specific atomic defects, known as nitrogen-vacancy (NV^-) centers, are responsible for producing stable and bright light signals. These defects emit light at specific energies with high efficiency and strong intensity, indicated by a high Debye-Waller factor. The study also revealed that slight structural changes in these defects can further enhance light emission properties. These findings provide a deeper understanding of quantum light generation and open new possibilities for designing efficient, integrated photonic devices for future quantum technologies.
Meher S. et al., Nano Letters, 2026.

2D MATERIAL ENABLES BUILT-IN IMAGE PROCESSING IN ELECTRONIC DEVICES

Modern imaging systems usually require separate hardware or software to process images after they are captured. In this study, researchers demonstrated a new approach where image processing can occur directly within the sensing device itself. They developed a device using a layered material called $LiInP_2Se_6$ combined with monolayer MoS_2 in a field-effect transistor structure. This system showed an unusual light response, where the electrical signal decreases under illumination, a phenomenon known as negative photoconductivity. The response could be controlled by light intensity and applied voltage. By using this unique behavior, the device was able to adjust image contrast directly at the sensor level without external processing. This means images can be modified in real time within the device itself. This work opens a new path for compact, energy-efficient vision technologies with built-in image processing capabilities.
Rasyotra A. et al., Nano Letters, 2026.

NANOTECHNOLOGY & SENSING

PRECISE NANOCLUSTERS ENHANCE DETECTION AT THE MOLECULAR LEVEL

Detecting molecules at very low concentrations is crucial for applications in chemistry, medicine, and environmental monitoring. In this study, researchers developed a highly sensitive detection system using atomically precise silver nanoclusters combined with gold nanotriangles. These nanoclusters behave like tiny molecules but usually produce weak signals due to interference from light emission. By integrating them with specially designed gold nanostructures, the researchers enhanced their signal using surface-enhanced Raman spectroscopy (SERS). This combined system significantly amplified molecular

DISCOVERY HIGHLIGHTS

signals, allowing clear detection even under strong laser conditions. The study revealed that both electromagnetic effects and charge transfer between materials contribute to this strong signal enhancement. This work demonstrates a powerful approach for ultra-sensitive molecular detection and opens new possibilities for advanced sensing technologies.

Manna S. et al., Nano Letters, 2026.

FLEXIBLE PAPER-BASED SENSOR ENABLES EFFICIENT AMMONIA DETECTION

Monitoring harmful gases like ammonia is important for environmental safety and health. In this study, researchers developed a simple, low-cost, and flexible sensor using a paper-based platform. The device was made by combining reduced graphene oxide (rGO) with polyaniline (PANI), forming a hybrid material on filter paper. The sensor showed strong performance at room temperature, detecting ammonia with high sensitivity. By optimizing the material composition and processing time, the researchers achieved a high response of up to 93% along with faster detection and recovery times. The flexibility of the paper substrate makes the sensor suitable for wearable applications and real-time monitoring. Its easy fabrication and affordability make it a promising solution for environmental monitoring, healthcare, and everyday safety applications.

Adhikari S. et al., ACS Applied Materials & Interfaces, 2026.

FLUORESCENT SENSOR ENABLES RAPID DETECTION OF NICOTINE EXPOSURE

Detecting nicotine exposure quickly and accurately is crucial for public health monitoring. Scientists from the Institute of Nano Science and Technology (INST), Mohali, have developed a novel fluorescent "turn-on" sensor capable of detecting nicotine and its stable biomarker, cotinine, in aqueous media and living cells. Nicotine is highly addictive, while cotinine remains longer in the body, making it a reliable indicator of tobacco exposure. Traditional detection methods are costly, time-consuming, and require complex procedures. To address this, researchers designed iron-based metal-organic framework (Fe-MOF) nanospheres porous, sponge-like structures that trap target molecules. When nicotine or cotinine enters these nanospheres, they trigger a visible fluorescence enhancement, producing a brighter signal due to electron transfer interactions. The sensor is highly selective, recyclable, biocompatible, and easy to use. This innovation offers a low-cost, efficient tool for real-time monitoring of tobacco exposure and opens avenues for advanced biosensing applications in healthcare and research.

Dhillon et al., Nanoscale, 2025.

EARTH SYSTEM SCIENCE & CLIMATE DYNAMICS

ENGINEERED CATALYST BOOSTS CONVERSION OF CO_2 INTO USEFUL FUELS

Converting carbon dioxide (CO_2) into useful fuels is a promising way to reduce pollution and produce clean energy. However, maintaining the right chemical state of catalysts during this process remains a major challenge. In this study, researchers developed an advanced catalyst by combining copper oxide (Cu_2O) with a special material called MXene. This design helped stabilize an important copper state (Cu^+), which is essential for forming multi-carbon fuel products. The engineered surface created a unique environment that improved CO_2 absorption and reaction efficiency. The system showed a threefold increase in activity and achieved high efficiency in producing valuable carbon-based compounds, while remaining stable for long durations. This work introduces a new strategy for designing efficient and durable catalysts, offering a promising route for sustainable fuel production from CO_2.

Bashir A. U. et al., ACS Applied Materials & Interfaces, 2026.

MICRODROPLET TECHNIQUE ENABLES RAPID FORMATION OF CATALYTIC NANORODS

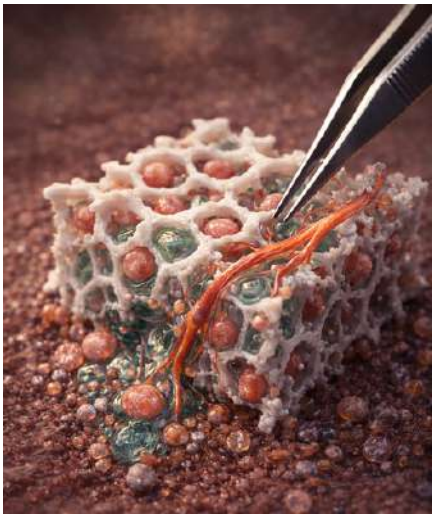
Developing efficient catalysts often requires complex and time-consuming synthesis methods. In this study, researchers introduced a

DISCOVERY HIGHLIGHTS

simple and rapid approach using tiny liquid droplets, known as microdroplets, to produce metal nanostructures within minutes. They successfully synthesized platinum and platinum–copper nanorods directly from simple solutions without using additional chemical reducing agents. This method is not only fast but also environmentally friendly, achieving nearly complete conversion in a single step. The resulting nanorods showed unique structures with high surface area, making them highly effective for catalytic reactions. When tested for nitrate reduction, they efficiently produced ammonia, an important industrial chemical. This work presents a sustainable and scalable method for creating advanced catalysts, opening new possibilities for environmentally friendly chemical processes.

Aswathi K. S. et al., Nanoscale Horizons, 2026.

BIOMATERIALS & TISSUE ENGINEERING



TARGETED DRUG DELIVERY SYSTEM IMPROVES TREATMENT OF RHEUMATOID ARTHRITIS

Rheumatoid arthritis is a chronic inflammatory disease that affects joints and reduces quality of life. In this study, researchers developed a targeted drug delivery system to improve the effectiveness of treatment while reducing side effects. They designed niosomes tiny vesicles loaded with the drug Baricitinib and coated with human serum albumin to enhance delivery to inflamed tissues. These nanocarriers were carefully optimized and tested in a rat model that mimics human arthritis. The results showed improved drug stability, sustained release, and higher therapeutic efficiency. Treated animals showed reduced inflammation, better joint condition, and improved overall health compared to standard treatment. This study highlights the potential of advanced drug delivery systems to enhance treatment outcomes and reduce toxicity, offering a promising strategy for managing rheumatoid arthritis.

Rani L. et al., Journal of Drug Targeting, 2026.

3D BIOPRINTING ADVANCES OFFER NEW HOPE FOR CORNEAL REPAIR

Corneal blindness is commonly treated through transplantation, but limited donor availability and complications create the need for alternative solutions. In this study, researchers developed a novel 3D bioprinting approach to create artificial corneal tissue. They designed a bioink combining GelMA and carboxymethyl chitosan (CMCh), which improves printability and structural stability. Using this bioink, high-resolution scaffolds were printed and tested for their physical and biological properties. The material showed good transparency, stability, and compatibility with corneal cells. Importantly, the printed scaffolds supported the growth and maintenance of stromal keratocytes without unwanted cell changes. This indicates that the system can mimic natural corneal tissue effectively. This work highlights a promising step toward developing lab-grown corneal substitutes, offering new possibilities for treating corneal damage and reducing dependence on donor tissues.

Vijayaraghavan R. et al., Journal of Materials Chemistry B, 2026.

ECOLOGY & ENVIRONMENTAL SCIENCE

SURROUNDING LANDSCAPES PLAY A KEY ROLE IN PROTECTING BIRD DIVERSITY

Habitat loss is a major threat to bird

DISCOVERY HIGHLIGHTS

species worldwide, often leading to local extinctions. While the size of forest patches is important, this study shows that the surrounding landscape also plays a critical role in determining species survival. Researchers analyzed global data covering nearly 2,000 bird species across forest fragments and island-like habitats created by deforestation and damming. They found that bird loss was higher in isolated forest islands compared to land-based forest fragments. Importantly, areas with more tree cover surrounding these fragments showed significantly lower rates of species loss, especially for forest-dependent birds. Even small forest patches were able to support diverse bird populations if nearby tree cover was maintained. This study highlights that conserving and restoring surrounding landscapes is just as important as protecting forests themselves for maintaining biodiversity.

Bueno A. S. et al., PNAS, 2026.

PLANT SIGNALS ATTRACT BENEFICIAL INSECTS TO FIGHT CROP PESTS

Crop pests like Tuta absoluta cause major damage to tomato production worldwide. In this study, researchers explored how plants naturally defend themselves by attracting beneficial insects. When tomato plants are attacked, they release specific chemicals called herbivore-induced plant volatiles (HIPVs). The researchers found that these signals strongly attract Harmonia axyridis, a beneficial insect that feeds on pests. Behavioral experiments confirmed this attraction, while molecular and computational analyses identified key odorant-binding proteins that help the

insect detect these plant signals. These proteins showed strong binding to specific plant-released compounds, explaining how insects recognize and respond to infested plants. This study highlights a natural and eco-friendly strategy for pest control, where plants and beneficial insects work together to reduce crop damage.

Mustapha T. et al., Journal of Agricultural and Food Chemistry, 2026.

CHEMICAL BIOLOGY & MOLECULAR MECHANISMS

PROTEIN KILLS BACTERIA WITHOUT DAMAGING THEIR MEMBRANES

Understanding how antimicrobial agents kill bacteria is important for developing new treatments. In this study, researchers discovered a unique way in which ribosomal protein S30 (RS30) destroys bacteria without forming pores in their membranes. Unlike many antibiotics that break or puncture the cell membrane, RS30 works by disturbing the electrical balance of the bacterial membrane. It binds specifically to bacterial membranes and restricts the movement of lipids, leading to subtle changes that disrupt membrane function. This causes a loss of membrane potential, which is essential for bacterial survival, ultimately leading to cell death. Importantly, RS30 showed little to no harmful effect on mammalian cells, indicating high selectivity. This study reveals a new antibacterial mechanism and offers a promising direction for designing safer and more effective antimicrobial therapies.

Mitra J. B. et al., Journal of Physical Chemistry Letters, 2026

CANCER PROTEIN RECOGNIZES DNA STRUCTURES TO PROTECT GENOME STABILITY

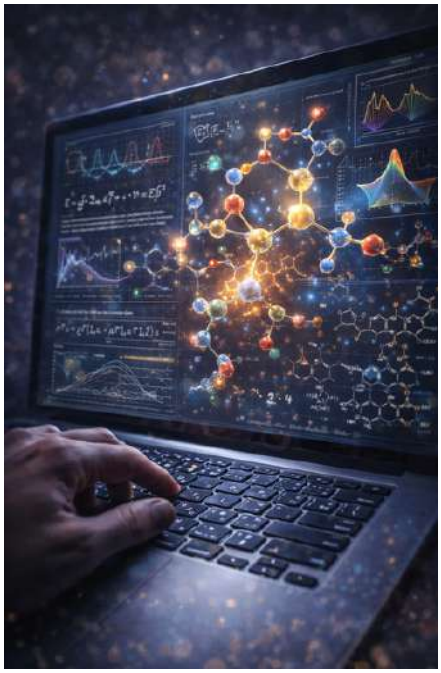
Maintaining DNA stability is essential for preventing diseases like cancer. In this study, researchers explored how

DISCOVERY HIGHLIGHTS

the BRCA1 protein, known for its role in cancer prevention, recognizes special DNA structures called G-quadruplexes found in human telomeres. They discovered that BRCA1 does not bind equally to all DNA shapes. Instead, it shows a stronger preference for a specific, more stable G-quadruplex form compared to others. This indicates that the structure and stability of DNA play a key role in how BRCA1 identifies its targets. The study also found that under oxidative stress, which damages DNA, BRCA1's ability to bind these structures decreases. This could affect its role in DNA repair and genome protection. These findings provide new insights into how BRCA1 maintains genome integrity and its potential role in cancer-related processes.

Kabir S. H. et al., Journal of Physical Chemistry Letters, 2026.

COMPUTATIONAL & THEORETICAL CHEMISTRY



NEW METHOD REVEALS HOW ENERGY MOVES IN COMPLEX QUANTUM SYSTEMS

Understanding how energy moves through quantum systems is important for technologies like solar energy and quantum computing. However, tracking these processes is difficult because such systems constantly interact with their surroundings. In this study, researchers developed an advanced computational method to analyze how energy flows in open quantum systems. The approach extends existing models by including real-world effects such as energy gain (pumping), loss (draining), and environmental interactions. Using this method, they were able to map detailed pathways of energy transport and observe how external conditions influence these routes. The study also demonstrated how steady energy flow can be maintained under combined effects of these processes.This work provides a powerful tool for studying complex quantum dynamics, offering deeper insights into energy transport in molecular and quantum systems.

Sharma D. et al., Journal of Chemical Theory and Computation, 2026.

FASTER COMPUTATIONAL METHOD IMPROVES STUDY OF COMPLEX MOLECULAR SYSTEMS

Accurately studying the electronic properties of molecules, especially those containing heavy elements, is computationally demanding. In this study, researchers developed a more efficient computational approach to calculate key properties such as ionization energies, electron attachment, and excitation energies. The method combines advanced techniques like Cholesky decomposition and frozen natural spinors to significantly reduce computational cost while maintaining high accuracy. It also introduces an improved framework to better describe excited states of molecules. The new approach was tested on medium to large molecular systems and successfully reproduced results comparable to standard high-level methods but with much faster performance. This work provides a powerful and cost-effective tool for studying complex molecular systems, enabling more efficient simulations in chemistry, materials science, and related fields.

Chakraborty S. et al., Journal of Chemical Theory and Computation, 2026.

ENVIRONMENTAL HEALTH & POLLUTION

CHILDREN AT GREATER RISK FROM RIVER METAL CONTAMINATION

Trace metal pollution in river systems poses a significant health threat, particularly to children. A recent study by scientists at the Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow, examined water samples from the Betwa–Yamuna confluence in Uttar Pradesh to assess human health risks associated with metal exposure. Unlike conventional methods that rely on average contamination levels, this study incorporated variability in exposure using advanced risk assessment models. Researchers measured dissolved metals such as arsenic, lead, and cadmium and applied Monte Carlo simulations to evaluate thousands of exposure scenarios. The

DISCOVERY HIGHLIGHTS

results showed that children face significantly higher non-carcinogenic risks, with hazard index values exceeding safe limits in about 67% of cases. Arsenic exposure also posed notable carcinogenic risks. The findings highlight how pollutants stored in river sediments can re-enter the water under changing conditions, increasing exposure. This study provides a robust framework for river health assessment and supports targeted pollution control and water safety policies.

Prasanna et al., Scientific Reports, 2026.

MICROPLASTICS DETECTED IN HIMALAYAN RIVERS OF DOON VALLEY

Microplastic contamination is emerging as a serious threat to freshwater ecosystems, and a recent study highlights its widespread presence in rivers of the Doon Valley in the Himalayan region. Researchers analysed water and sediment samples from five major rivers Sahastradhara, Song, Bindal, Asan, and Tons to assess the occurrence and characteristics of microplastics. Using advanced techniques such as density separation, microscopy, and FTIR spectroscopy, the study confirmed the presence of microplastics in all sampled rivers. Fibers and pellets were the most common forms, with particle sizes ranging from microscopic levels to over a millimetre. The dominance of fine particles is particularly concerning, as they can easily enter food chains and impact aquatic life and human health.Polyethylene was identified as the most abundant polymer, followed by PET and polyp-

ropylene, indicating both domestic and industrial pollution sources. This study provides crucial baseline data and highlights the urgent need for monitoring and sustainable management of river systems.

Kalita H. et al., Water Practice and Technology, 2026.

ANTIBIOTIC RESISTANCE EMERGING IN URBAN RIVER SEDIMENTS

Urban river systems are increasingly becoming hotspots for antibiotic resistance, posing a growing threat to environmental and human health. A recent study investigated riverbed sediments from subtropical river basins in northern India, comparing peri-urban and heavily urbanized regions to understand how pollution influences microbial communities and resistance patterns.

Researchers analysed sediment samples across different seasons and found that highly urbanized river stretches carried significantly higher levels of contaminants, including heavy metals and antibiotic residues. These conditions were strongly linked to the proliferation of antibiotic-resistant bacteria (ARB), including clinically relevant pathogens such as Pseudomonas, Staphylococcus, and Acinetobacter. The study also revealed that dominant bacterial groups, particularly Pseudomonadota and Bacillota, thrive in these polluted environments. Seasonal variations played a key role, with summer and monsoon conditions promoting pathogen growth, while winter conditions favored the development of drug resistance. Importantly, the combined presence of heavy metals and antibiotics was found to accelerate the spread of resistance, highlighting a synergistic pollution effect. These findings emphasize that river sediments are not just passive reservoirs but active environments where antimicrobial resistance can evolve and spread. The study provides important insights for environmental monitoring and supports the need for stricter pollution control and wastewater management policies in rapidly urbanizing regions.

Pandey, et al. (2026), Environmental Research

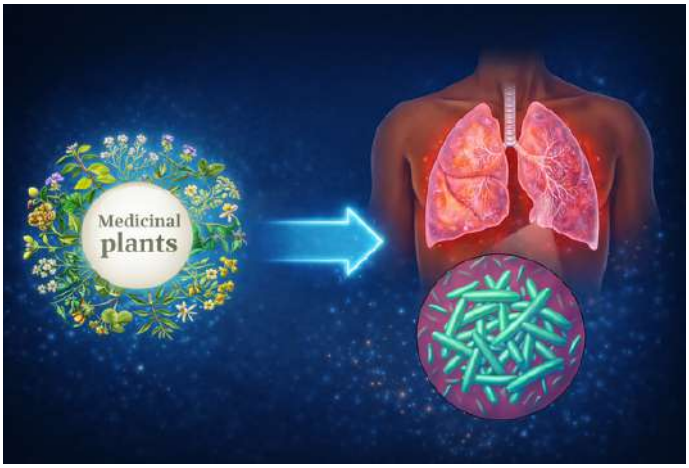
| SCIENCE IN FOCUS |

SCIENCE IN FOCUS

India Launches AI-Driven Initiative to Predict Preterm Births

India has launched an AI-driven initiative under the GARBH-INi programme to predict preterm births, a major cause of neonatal mortality. Led by the Department of Biotechnology (DBT), the programme focuses on developing data-driven solutions tailored to Indian populations. It has created one of South Asia's largest pregnancy cohorts, enrolling around 12,000 women and generating extensive data, including over 1.6 million biospecimens and one million ultrasound images. By integrating clinical data, genomics, microbiome analysis, and imaging, researchers are identifying early indicators of preterm birth risk. Key outcomes include AI-based pregnancy dating models, microbiome-based predictors, and genetic markers for early detection. The initiative also established a national biorepository and the GARBH-INi-DRISHTI platform to enable data sharing and collaboration. This effort aims to reduce reliance on imported technologies, improve maternal and child health, and strengthen India's healthcare innovation ecosystem, aligning with the country's vision for science-led development by 2047.

Press Information Bureau (PIB), Government of India. 23 March 2026.



India Launches First Global Clinical Study Integrating Ayurveda with Modern TB Treatment

India has launched the world's first clinical study to evaluate integrating Ayurveda with modern Anti-Tuberculosis Treatment (ATT). Led by the Department of Biotechnology and the Ministry of Ayush, the initiative aims to develop a holistic, patient-centric approach to TB care.

With India accounting for nearly 25% of the global TB burden, this study addresses challenges such as drug toxicity, undernutrition, and immune suppression that persist despite effective treatments. Around 1,250 newly diagnosed TB patients will be enrolled across multiple institutions. Ayurveda will be tested as a supportive therapy alongside standard treatment, assessing outcomes like body weight, nutritional status, disease progression, safety, and overall well-being.

Advanced tools, including MRI, metabolomics, immune profiling, and single-cell RNA sequencing, will provide deeper insights into treatment effects. This "whole-of-science" approach aims to improve recovery, especially in drug-resistant cases, and supports India's goal of a TB-Free nation while offering a potential global model for integrative healthcare.

Press Information Bureau (PIB), Government of India. 24 March 2026.

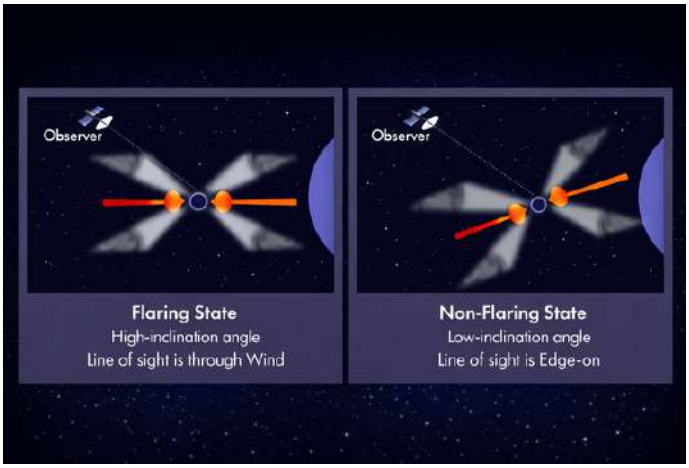
| SCIENCE IN FOCUS |

SCIENCE IN FOCUS

India Invites Nominations for Rashtriya Vigyan Puraskar 2026 to Recognize Scientific Excellence

The Government of India has opened nominations for the Rashtriya Vigyan Puraskar (RVP) 2026, a prestigious initiative recognizing excellence in science, technology, and innovation. Administered by CSIR under the Ministry of Science & Technology, the awards aim to honor contributions that advance India's scientific progress and national development. The awards span multiple disciplines, including agriculture, biology, engineering, environment, medicine, physics, and space science. They are presented in four categories: Vigyan Ratna for lifetime achievement, Vigyan Shri for distinguished contributions, Vigyan Yuva–Shanti Swarup Bhatnagar Award for young scientists under 45, and the Vigyan Team Award for collaborative research excellence. A key feature is its inclusive and transparent nomination process, allowing both institutional and self-nominations through an online portal. By encouraging broad participation, the initiative seeks to recognize deserving talent, foster innovation, and strengthen India's scientific ecosystem, supporting the vision of a "Viksit Bharat" through science-led development.

Press Information Bureau (PIB), Government of India, 28 March 2026.



Indian Scientists Uncover Mystery Behind Rare X-ray Bursts from Distant Space Objects

Scientists from the Raman Research Institute (RRI), Bengaluru, have explained unusual X-ray bursts from a distant ultraluminous X-ray source (ULX), M74 X-1. ULXs are extreme systems where a dense object, such as a black hole or neutron star, pulls matter from a nearby star. This material forms an accretion disk, releasing intense X-rays as it spirals inward. Using long-term data from NASA's Chandra and ESA's XMM-Newton observatories, researchers studied irregular flares that did not follow a fixed pattern. They found that these bursts arise from a wobbling motion of the accretion disk. As the disk tilts, powerful winds move in and out of the observer's line of sight, causing fluctuating brightness similar to a "hide-and-seek" effect. The central object is likely a black hole about seven times the Sun's mass, though similarities with neutron stars remain. This study improves understanding of extreme cosmic systems and high-energy astrophysics.

Press Information Bureau (PIB), Government of India. 30 March 2026.

| SCIENCE IN FOCUS |

SCIENCE IN FOCUS

Scientists Transform Battery Waste into High-Performance Material for Fuel Cells

Scientists in India have developed a novel method to convert waste graphite from lithium-ion batteries into a high-performance material for fuel cells, addressing both battery waste and clean energy challenges. With the rapid growth of electric vehicles and energy storage systems, managing used batteries has become a major environmental concern, while fuel cells require efficient and durable catalysts. Researchers at ARCI recovered graphite from spent batteries and chemically exfoliated it to enhance its surface area and properties. When combined with platinum-based catalysts, the modified graphite formed a conductive network that improved electron and oxygen movement. It also reduced harmful effects like methanol oxidation and carbon monoxide poisoning, which typically degrade catalyst performance. An optimal composition of about 10% exfoliated graphite showed improved efficiency, stability, and durability, especially in acidic conditions. This innovation highlights a sustainable approach to transforming waste into valuable materials, supporting circular economy solutions and advancing clean energy technologies.

Press Information Bureau (PIB), Government of India., 30 March 2026.

Scientists Develop Brain-Like Sensor Inspired by Frogs to Enable Energy-Efficient Electronics

Scientists in India have developed a humidity-responsive neuromorphic sensor inspired by frog behaviour, capable of mimicking brain-like sensing, processing, and memory. This innovation addresses challenges of high energy consumption and complex data handling in modern electronics, especially in AI and edge computing systems. Researchers at JNCASR designed a single-device platform that integrates sensing, memory, and processing using supramolecular nanofibers. These nanofibers respond to environmental humidity, generating electrical signals similar to neural activity. Inspired by moisture-sensitive frog neurons, the device exhibits synaptic features such as learning, memory, and adaptability. It can even "remember" past stimuli, a key biological trait. The sensor forms a nanofiber network on an electrode surface and shows dynamic responses signal strengthening, weakening, and plasticity based on humidity and light conditions. This breakthrough reduces energy use by eliminating separate processing units and opens pathways for smart sensors, wearable devices, and efficient neuromorphic computing systems.

Press Information Bureau (PIB), 9 April 2026.

| SCIENCE IN FOCUS |

SCIENCE IN FOCUS

India Develops 'SARAL AI' to Simplify Scientific Research for Public Access

India is strengthening science communication through 'SARAL AI', an AI-driven platform developed under the Anusandhan National Research Foundation (ANRF). The initiative aims to convert complex scientific research into simple, accessible formats for the public, students, and policymakers. SARAL AI transforms research papers, patents, and findings into podcasts, short videos, posters, presentations, and social media summaries. It also supports dissemination in 18 Indian languages, improving accessibility across diverse regions. This addresses a key gap by making advanced research understandable and relatable. The initiative aligns with India's broader vision of connecting science with society. Alongside this, ANRF is promoting mission-driven programmes under 'MAHA' to tackle challenges such as climate change, healthcare, and energy efficiency. Additional measures include institutional support systems and digital communication platforms to assist researchers. By simplifying knowledge and expanding outreach, SARAL AI is expected to enhance public engagement, support evidence-based decisions, and strengthen India's research ecosystem.

Press Information Bureau (PIB), Government of India. 13 April 2026.

Scientists Explore Possibility of Black Holes in Dwarf Galaxies

Scientists in India are advancing our understanding of the universe by investigating whether some of the smallest galaxies, known as dwarf spheroidal galaxies, can host black holes. These galaxies, which orbit the Milky Way, are faint, contain very little gas, and are dominated by dark matter, making the detection of black holes extremely challenging. Researchers from the Indian Institute of Astrophysics developed advanced models that combine the effects of stars, dark matter, and a potential central black hole to study how stars move within these galaxies. By analyzing stellar motion data, they were able to estimate the possible mass of black holes, if present. Their findings suggest that while massive black holes are not required to explain the data, smaller or intermediate-mass black holes could exist within these systems. This research is important because it helps answer fundamental questions about how black holes formed and evolved in the early universe. It also shows that the relationship between black hole mass and galaxy properties may extend even to the smallest galaxies, providing a unified understanding across cosmic scales. The study further compares observational results with theoretical models of black hole growth, including processes such as gas accretion, stellar capture, and galaxy interactions. These models predict black hole masses that align well with the limits observed in dwarf galaxies. By exploring these, scientists are bringing us closer to understanding the origin and evolution of black holes across the universe.

Press Information Bureau (PIB), Government of India. 17 April 2026.

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 WARNING BEFORE THE FALL

Manoj had always loved riding his bike. It wasn't just a way to get to college it was his freedom, his space to think, and sometimes his escape from a busy day. One evening, as he was riding home through a crowded street, something felt slightly off. The bike wobbled just a little. At first, he ignored it, thinking it was just the uneven road. But within seconds, the wobble became stronger. Manoj slowed down quickly and pulled over. His tyre had gone flat. It was a puncture. He stood there, relieved that he had managed to stop safely, but a thought lingered in his mind what if this had happened at high speed?

A few weeks later, Manoj came across a new safety system designed for two-wheelers. Curious, he decided to install it on his bike. The technician explained that the system used small sensors placed inside the tyre to constantly monitor its condition. These sensors checked air pressure, vibrations, and even detected if a sharp object like a nail had hit the tyre. All this information was sent to a small control unit in the bike, which analyzed the data in real time. "It's like your tyre can speak now," the technician said with a smile.

For a few days, Manoj didn't notice anything unusual. The system worked silently in the background. But one rainy afternoon, while riding on a slippery road, everything changed. Suddenly, a warning sound beeped, and a message flashed on his dashboard: "Possible puncture detected." At the same moment, his phone vibrated with the same alert. Manoj was surprised but reacted immediately. He slowed down and stopped safely by the roadside. When he checked the tyre, he found a small nail embedded in it. The tyre wasn't completely flat yet, but air was slowly leaking out.

This time, Manoj wasn't reacting to a problem he was preventing one. The system had detected a slight drop in air pressure along with unusual vibrations, confirming that something was wrong even before he could feel it. That early warning made all the difference. From that day on, Manoj felt more confident on the road. The system continuously monitored his tyres, adjusting its sensitivity based on speed, road conditions, and temperature. It didn't rely on guesswork; it made smart decisions based on real data. For riders like Manoj, especially in places where two-wheelers are a primary mode of transport, this innovation could be a lifesaver. Because sometimes, safety isn't about reacting quickly it's about knowing early. And in that small moment between danger and control, a simple warning can change everything.

INNOVATION

Gaikwad, R. B., Kenvat, R., Khetmalis, V. G., & Mehetre, R. A. (2026). System and method for real-time detection of punctures in tyres of two-wheelers. Patent Number: 586781.

By Anantrao Pawar College Of Engineering & Research (APCOER), Ramana, S. No. 103, Shahu College Rd, Parvati, Pune, Maharashtra 411009, India.

| By Dr. Priyanka

THE MILK THAT TOLD THE TRUTH

Durga woke up early every morning to help her mother prepare tea for the family. In their home, milk was an essential part of daily life used in tea, breakfast, and cooking. One day, as Durga poured milk into a pot, her mother paused and said thoughtfully, “Sometimes I wonder... is this milk really pure?” Durga looked at it carefully. It appeared perfectly normal white and smooth. But she had heard stories about milk being mixed with water, starch, or even harmful chemicals. The biggest problem was simple: you couldn’t tell just by looking. That question stayed in her mind.

A few days later, Durga visited a nearby dairy collection center. There, she noticed a small device placed on a table. It looked simple, like a compact box with a lid and a small digital screen. Curious, she asked the technician, “What is this?” He replied, “This is a milk quality detection device. It helps us check whether milk is fresh, spoiled, or adulterated.” Durga was surprised. “How can it know that so quickly?” she asked.

The technician demonstrated. He poured a small amount of milk into the device and closed the lid. Inside, tiny sensors started working silently. One sensor checked the color of the milk, another detected gases produced by bacteria, a third measured density to see if anything was mixed into it, and another monitored the temperature. Within seconds, the screen displayed the result: “Status: Fresh Milk.” Durga was amazed. “That was so fast!” she said. The technician explained that the system uses smart technology and Artificial Intelligence (AI) to analyze all the data and compare it with known patterns of fresh and spoiled milk.

He then showed her a QR code on the screen. “Scan this,” he said. Durga used her phone, and instantly detailed information appeared milk quality, storage condition, and safety status. It felt like the milk was finally able to tell its own story.

When Durga returned home, she told her mother everything. Soon, they started buying milk from a vendor who used the same system. Now, each batch came with a QR code. Before using it, Durga would quickly scan it. There was no more guessing or worrying. One day, the system detected that a batch of milk was spoiled, and the vendor immediately removed it. What could have been a health risk was avoided.

Durga realized something important. Safety is not just about reacting quickly it is about knowing early. With this simple device, technology had brought trust back into something as basic as milk. From then on, for Durga, milk was no longer just a daily routine it was a symbol of safety, science, and confidence.

INNOVATION

Patra, D., Veer Surendra Sai University of Technology, Kar, B. P., Tripathy, A. B., Jena, P. C., Das, S. R., Samparna, S. S., Bishal, P., & Das, S. S. (2026). Milk quality detection equipment. Patent Number: 586228.

By Veer Surendra Sai University of Technology, Burla Surendra Sai Marg, Sambalpur, Odisha, India, 768018.

When Indigo Inspired Innovation: Creating the Future of Sulfur-Based Dyes

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| Scientific Profile | | Organization Link | | Research Lab Page | | Factors Press |

Areas of Expertise: Organic Synthesis | Sustainable Catalysis | Homogeneous Catalysis | Metal Nanocatalysis | Halogen-Bonding Catalysis

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| Scientific Profile | | Organization Link | | Research Lab Page | | Factors Press |

Areas of Expertise: Organic Synthesis | Homogeneous Catalysis | Organocatalysis | Asymmetric Synthesis

For centuries, indigo has been known as the dye of deep blue beauty, coloring fabrics, art, and history itself. But in our laboratory, indigo inspired something beyond color: a new way to create its sulfur-rich chemical cousins in a cleaner and greener way.

Thioaurones and thioindirubins, structurally close relatives of indigo dyes, are prized not only for their vivid chemistry but also for their potential in medicines, smart materials, and advanced technologies, yet making them has long been troublesome. Traditional methods often involve unpleasant sulfur smells, expensive chemicals, and harsh reaction conditions, making large-scale production difficult and inefficient.

What changed the story was a simple idea: replacing foul-smelling sulfur reagents with an odorless alternative, potassium ethyl xanthate, a stable and easy-to-handle sulfur source (as sulfur surrogate) that became the heart of our patented invention. With the help of a copper catalyst and iodine, we found a way to transform simple starting materials into valuable sulfur-based dye molecules in one smooth step under open-air conditions.

By replacing unpleasant sulfur source with an odorless alternativ, this process makes sulfur chemistry safer and more practical for both laboratories and industry. What once required complicated multi-step procedures can now be done in a simpler, cleaner process that reduces waste and improves efficiency.

For the first time, the copper catalyst and xanthate have been combined to synthesise both thioaurones and thioindirubins through a unified strategy. More than a laboratory success, it is a step toward sustainable chemistry, where innovation protects both efficiency and the environment.

From the ancient legacy of indigo to the future of green molecular design, this work gives new meaning to a timeless color story.

Patent Reference:

Cu-catalyzed practical domino synthesis of thioaurone and thioindirubin from commercially available starting materials using odorless xanthate as a sulfur surrogate, Indian Patent No: 402159.

Targeting Inflammation at Its Core: A Novel Potent IKKβ Inhibitor for Chronic Inflammatory Diseases

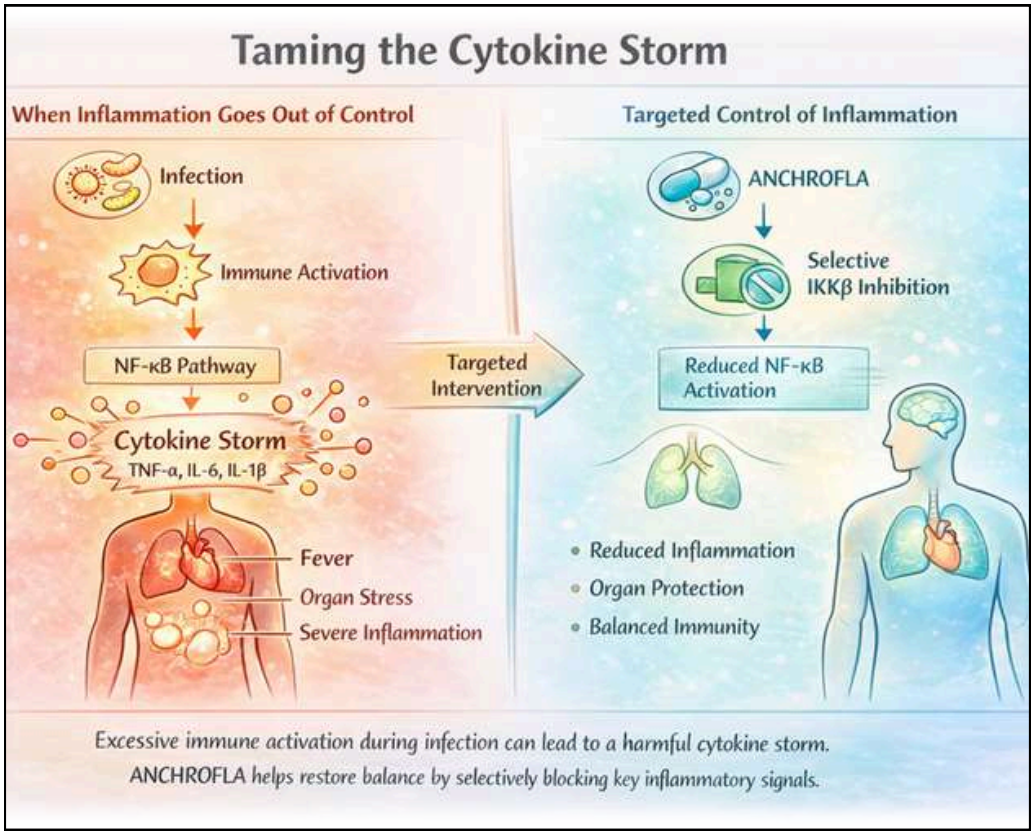
Prof. Mirza S Baig
INDIAN INSTITUTE OF TECHNOLOGY (IIT) - INDORE, MADHYA PRADESH, INDIA

Scientific Profile | Organization Link | Research Lab Page | Factors Press

Areas of Expertise: Inflammation Biology | Drug Discovery Therapeutics

Chronic inflammatory diseases (CIDs) have emerged as one of the most pressing global health challenges of our time. Responsible for nearly 41 million deaths annually, these conditions disproportionately affect low- and middle-income countries, where approximately 77% of fatalities occur. In India alone, chronic diseases account for nearly 63% of all deaths, underscoring their profound impact on both healthcare systems and quality of life.

At the heart of many life-threatening disorders including atherosclerosis, cancer, and autoimmune diseases—lies persistent, dysregulated inflammation.



Despite advances in biomedical research, developing therapies that can precisely modulate inflammatory pathways without disrupting essential physiological processes remains a significant challenge. One of the central regulators of inflammation is the NF-κB signaling pathway, a master controller of genes involved in immune and inflammatory responses. Activation of this pathway is tightly regulated by the IκB kinase (IKK) complex, particularly its two catalytic subunits, IKKα and IKKβ. Among these, IKKβ plays a dominant role in driving NF-κB activation in response to key inflammatory stimuli such as TNF-α, IL-1β, and lipopolysaccharide (LPS).

In this context, we introduce a novel small-molecule IKKβ inhibitor designed to modulate this critical pathway. The compound demonstrates the ability to attenuate NF-κB activity and reduce the production of harmful inflammatory mediators, highlighting its therapeutic potential across a broad spectrum of chronic inflammatory conditions. Importantly, the compound minimizes off-target interactions, offering a safer therapeutic profile. As the burden of chronic inflammatory diseases continues to rise, targeted strategies such as IKKβ inhibition represent a promising direction for next-generation therapeutics.

Patent Reference:

Mirza S Baig, Shivmuni Sarup (2026). A compound inhibiting chronic inflammatory disease/s and method thereof. Indian Patent No. 581448.

Closing the Loop: Converting Municipal Solid Waste into Functional Soil Amendments

Dr. Remya Neelancherry
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Scientific Profile | Organization Link | Research Lab Page | Factors Press

Areas of Expertise: Waste Management | Biochar Technology | Sustainable Agriculture | Environmental Sustainability

Modern societies are confronting a paradox at the intersection of waste management, agricultural and environmental sustainability. While agricultural productivity must increase to support a growing global population, enormous quantities of food are simultaneously discarded as municipal solid waste (MSW). According to global estimates, food waste accounts for a significant share of MSW streams, contributing to greenhouse gas emissions, landfill overburden, and resource inefficiency. At the same time, agricultural soils are progressively losing organic carbon, nutrient balance, and moisture-retention capacity due to intensive farming practices and excessive reliance on synthetic fertilizers. These parallel challenges highlight the urgent need for technologies that move beyond waste disposal toward resource recovery and circular utilization.

Scientific attention has therefore shifted toward thermochemical conversion processes capable of transforming organic residues into functional materials with agricultural and environmental value. Among these approaches, biochar production has emerged as a promising strategy because it simultaneously enables waste valorisation, soil restoration, and long-term carbon sequestration. However, conventional biochar production methods often require homogeneous feedstocks, prolonged heating durations, and energy-intensive operations, limiting scalability under real MSW conditions. Addressing these limitations requires innovations that combine process efficiency, feedstock flexibility, and engineered functionality of the final material.

In this context, our patented technology produces nutrient-rich biochar from commingled food waste termed as FertoChar, via co-activation and microwave-assisted co-pyrolysis (MACP) — a rapid, energy-efficient alternative to conventional pyrolysis. Unlike traditional waste-processing methods that rely on prolonged external heating, microwave-assisted systems generate volumetric heating, enabling faster reaction kinetics and uniform thermal conversion.

Designed specifically for real-world MSW conditions, the process accepts commingled food waste typical of the Indian waste stream, including rice, pulses, breads/rotis, and fruit and vegetable peels. Notably, the technology tolerates the presence of low-density polyethylene (LDPE), eliminating the need for labour-intensive segregation. Microwave susceptors, such as granular activated carbon, silicon carbide, or zirconium–silica alloy, enhance energy absorption, enabling efficient conversion at controlled microwave power (600–900 W) over short processing time of 10 – 30 minutes.

Ferto-CHAR is not merely a carbon residue but a functional soil-engineering material. Characterized by near-neutral pH (~6.5) and porous structure spanning 0.5–50 µm, FertoCHAR acts as a micro-reservoir for water and nutrients. With water absorbance exceeding 41% and augmented bulk density (~0.48 g/cm³), FertoCHAR significantly improves soil physical properties. Experimental validation demonstrates that adding approximately 8 wt% FertoCHAR enhances soil water-holding capacity by nearly 62.5%, a critical advantage for water-stressed agricultural regions.

The nutrient delivery characteristics of the FertoCHAR were further examined through controlled modification using urea intercalation, enabling its application as a controlled-release fertilizer. The modification increases nitrogen content while largely preserving the inherent pore structure, enabling gradual nitrate release over extended periods. Nitrogen release behaviour from the modified FertoCHAR approaches levels observed in conventional fertilizers, indicating its suitability

Patent Reference:

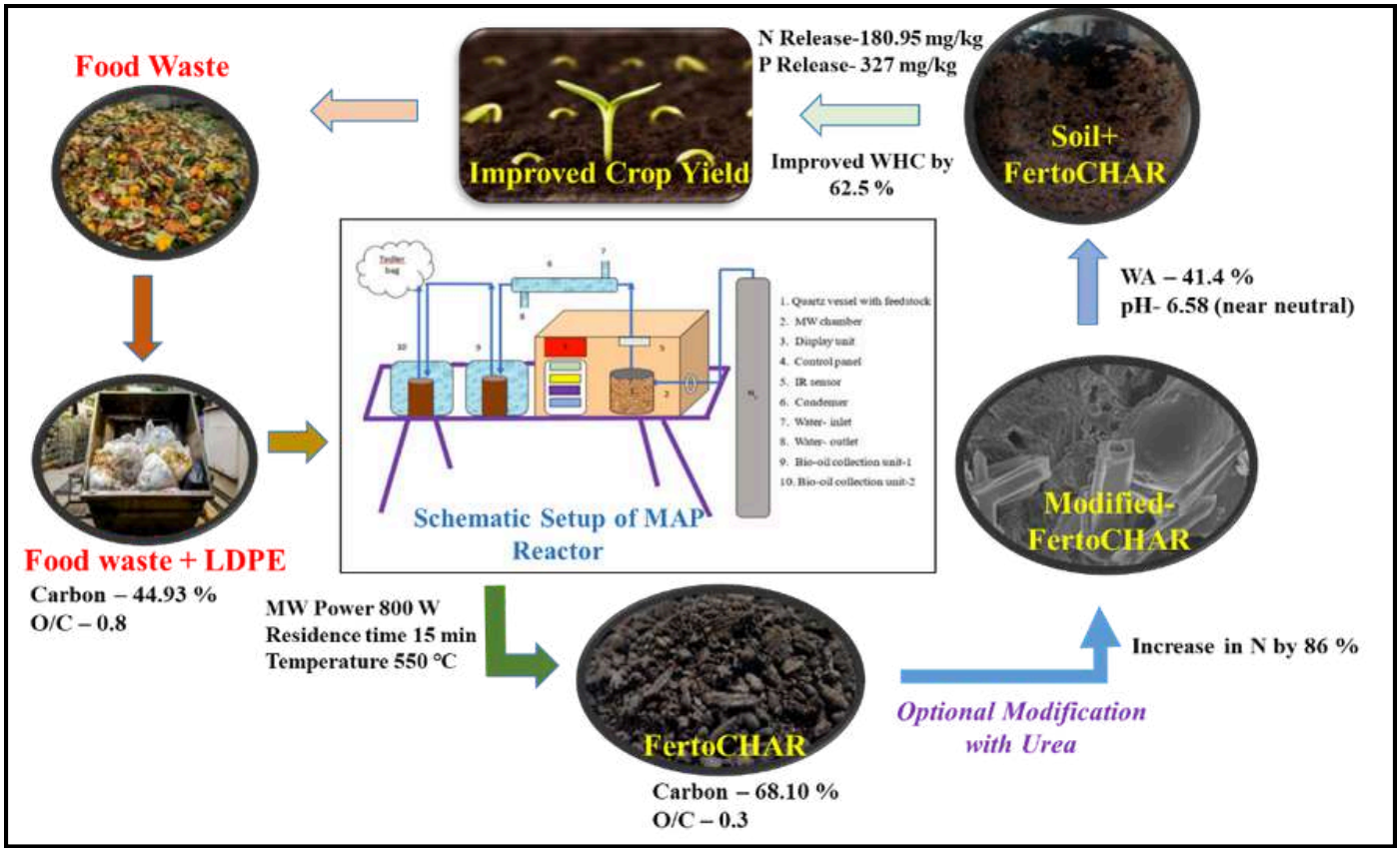
Dr. Remya Neelancherry, Rejeti Venkat Srinadh (2026), FertoCHAR-Commingled food waste derived organic fertilizer prepared by microwave-assisted catalytic pyrolysis, Indian Patent no: 580021

as an alternative nutrient source under controlled conditions. Phosphorus release performance remains comparable to that of conventional diammonium phosphate (DAP), achieving similar equilibrium availability. Together, these release characteristics suggest that FertoCHAR can support balanced nutrient supply while potentially improving nutrient retention within soil systems.

From a carbon management perspective, FertoCHAR exhibits an oxygen-to-carbon ratio (~0.31), indicative of high aromatic stability and corresponding to an environmental persistence of 100–1000 years. Such longevity allows the material to function as a carbon sink, linking agricultural productivity with climate mitigation. Biological assessments further confirm negligible phytotoxicity, with germination indices approaching 93%, demonstrating compatibility with plant growth systems.

Beyond material innovation, this approach highlights a systems-level model that transforms MSW streams into resources for regenerative agriculture. By combining microwave engineering, material science, and nutrient management, this invention redefines commingled food waste as a resource capable of restoring soil health, improving fertilizer efficiency, and contributing to long-term carbon sustainability. This patented process integrates waste conversion and resource recovery within a compact microwave-based pyrolytic system that produces FertoCHAR alongside bio-oil and syngas streams. This multi-product valorisation enhances overall process efficiency and supports decentralized waste management models aligned with circular economy principles.

In an era demanding climate-resilient agriculture and sustainable resource cycles, such innovations signal a transition from waste disposal toward waste-driven soil regeneration — turning yesterday's leftovers into tomorrow's productiveness.



(a) Sputtering system installed at the cleanroom facility of NIT Meghalaya, and (b) interior view of the sputtering chamber used for thin-film deposition.

Patent Reference:

Dr. Remya Neelancherry, Rejeti Venkat Srinadh (2026), FertoCHAR-Commingled food waste derived organic fertilizer prepared by microwave-assisted catalytic pyrolysis, Indian Patent no: 580021

From Dots to Decisions: Transforming Point Clouds to Meaningful Insights

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Scientific Profile | Organization Link | Research Lab Page | Factors Press
Areas of Expertise: Geoinformatics | Remote Sensing |Satellite image Processing | LiDAR Data Analytics | Spatial Data Modelling | Geographic Information Systems (GIS)

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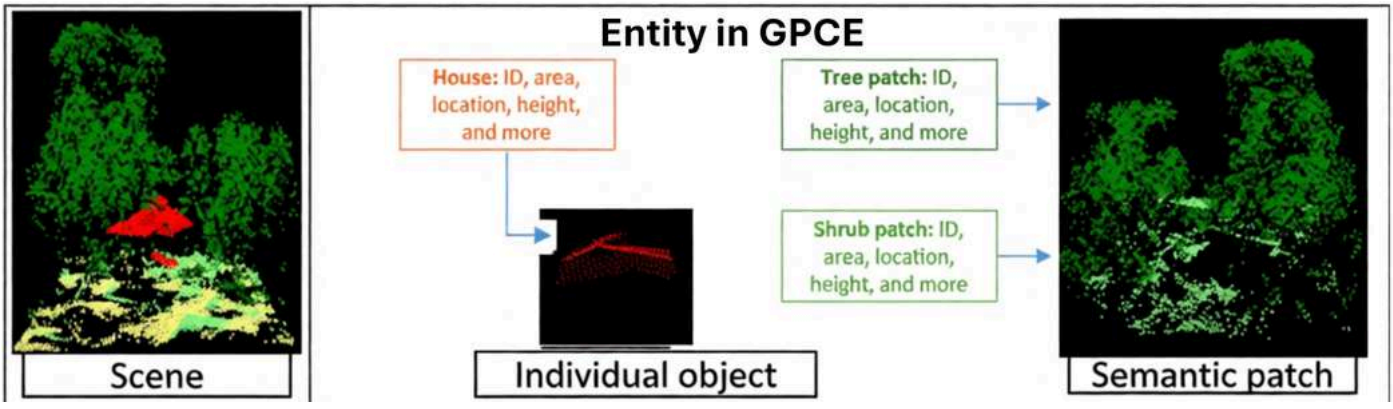
Areas of Expertise: Point Cloud Processing | Geospatial Science | LiDAR Data Analytics | Policy Making | Remote Sensing | Urban and Environmental Applications

Across the globe, the natural and man-made infrastructure systems are becoming more interconnected and complex, leading to a greater need for analysis-ready spatial data for governance, planning, monitoring changes, or making informed decisions. In this context, having accurate data is not sufficient. What truly matters is the ability to interpret data quickly and effectively for empirical decision-making. Three-dimensional mapping with technologies such as LiDAR (Light Detection and Ranging) provides depth and thus structure, enabling accurate representations of cities, landscapes, and infrastructure. Using LiDAR, the 3D data is generated as a collection of millions or even billions of spatial points, that collectively represent a region. While point clouds are rich in geometric detail but they lack meaning. Together, they represent positions and shapes, but direct extraction of information or utilitarian queries from point clouds was limited by the lack of meaning associated with each point and their large volume. This gap between the available or acquired point cloud data and their meaningful interpretation restricts their practical use. To address this challenge, we developed Geosemantic Point Cloud Enrichment (GPCE), a framework that transforms classified point cloud data into intelligent, analysis- and application-ready data.

GPCE morphologically transforms point clouds by adding a layer of intelligence. It enables us to understand not just whe-



Patent Reference:

A. M. Ramiya and J. Vijaywargiya, Geosemantic Point Cloud Enrichment (GPCE) for Spatio-Empirical Decision-Making, Indian Patent Number: 581534.

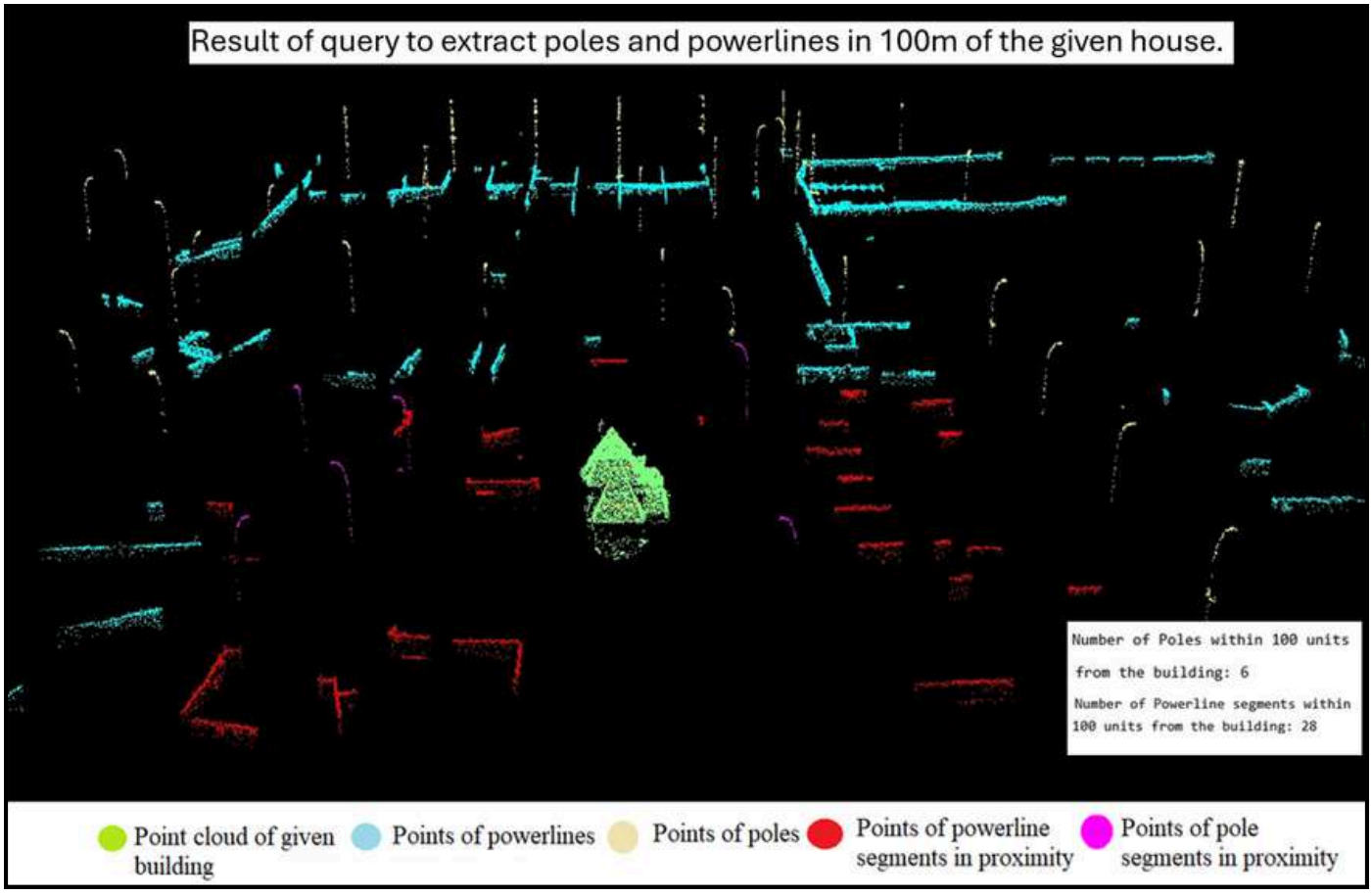
re something is in the large point cloud datasets, but also what it is and how it relates to its surroundings. Instead of treating points as isolated units, GPCE groups them into meaningful entities, such as a set of points that represent a building, a group of trees, a section of a power line, etc., and enriches them with both geospatial and contextual information.

This results in query output that serves both as information for empirical decision-making and as point clouds for perceiving a real scenario. For example, with GPCE, users can:

- Identify individual objects in a dataset
- Query specific features of the object, such as buildings above a certain height
- Track spatial and temporal changes in an area
- Integrate point clouds with socio-economic and Geographic Information Systems (GIS) data.

GPCE introduces structure, meaning, and context to an otherwise abstract dataset. This transforms point clouds into an analysis and application-ready dataset. The GPCE framework is a bimodular architecture encompassing Entity Point Cloud Storage (EPS) and the Entity Data Model (EDM). EPS stores enriched point-level data, while EDM manages entity-level details and relationships. These modules are connected using an ontological structure that links each point to an entity in space. An entity could be an individual object or a semantic patch of objects.

The GPCE framework accommodates variations in point density, ensures consistent representation of diverse entities in the dataset, and supports dynamic updates. This allows the data to remain relevant, and with the new data, changes can be monitored and updated. GPCE shifts the point clouds from geometric representation to an entity-based geosemantic framework for empirical decision making and introduces a new paradigm for direct utility of point clouds in various applications. It enables multi-dimensional data analysis by combining spatial and non-spatial information with point clouds. Overall, GPCE enriches the point clouds to extract information and relevant point clouds for applications, including urban planning, infrastructure management, environmental monitoring, and disaster response, that require timely and accurate insights.



Patent Reference:

A. M. Ramiya and J. Vijaywargiya, Geosemantic Point Cloud Enrichment (GPCE) for Spatio-Empirical Decision-Making, Indian Patent Number: 581534.

Plastic Recycling: A lost cause or a reversible healing in the development

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Scientific Profile | Organization Link | Research Lab Page | Factors Press

Areas of Expertise: Polymer Design | Sustainable Materials | Recycling Chemistry

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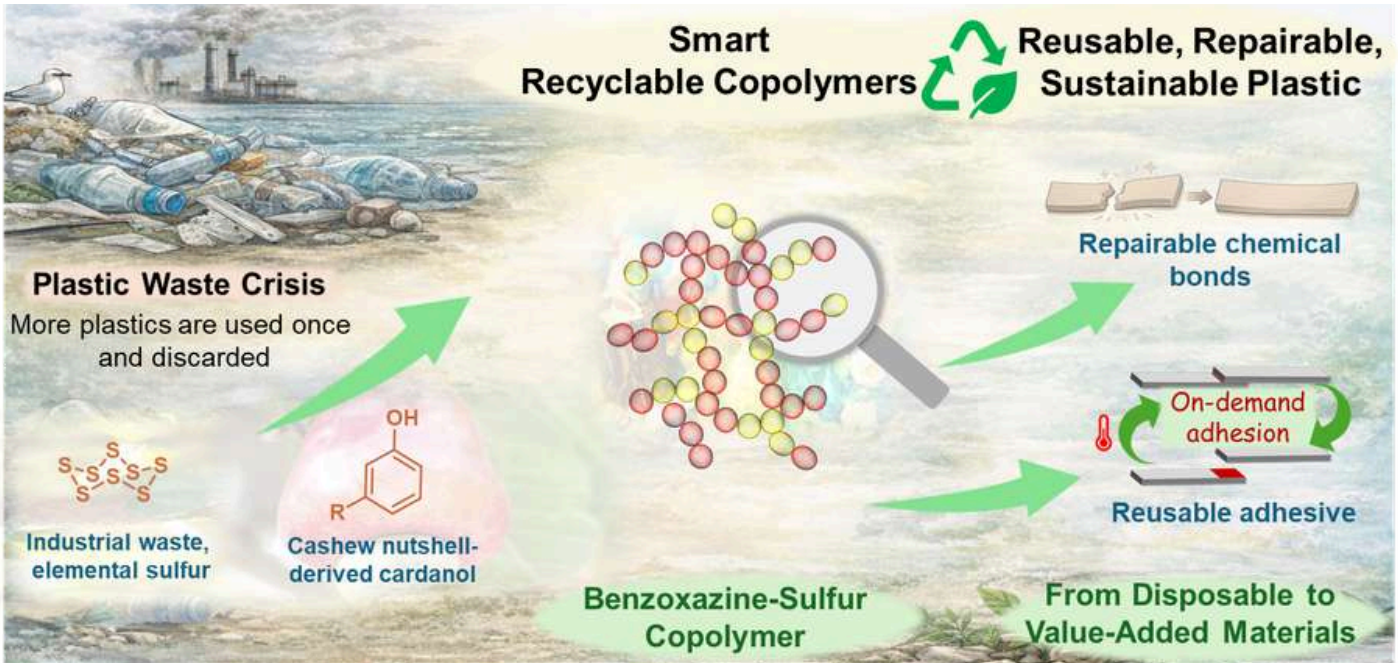
Areas of Expertise: Polymer Chemistry | Material Chemistry | Polymer Recycling

Plastics are deeply woven into modern life. From packaging and healthcare to transportation and construction, they offer a unique combination of durability, light weight, versatility, and cost-effectiveness. In many cases, plastics even reduce overall energy consumption and greenhouse gas emissions compared to traditional materials like glass or metals. Yet, this very durability has created one of the most pressing environmental challenges of our time. Today, more than 430 million tons of plastic are produced annually, and nearly two-thirds of this becomes waste after a single use. If current trends continue, global plastic waste is expected to nearly triple by 2060, posing serious threats to ecosystems, wildlife, and human health.

Completely eliminating plastics is neither practical nor desirable given their societal benefits. Instead, the focus is shifting



Patent Reference:

Bimlesh Lochab, BENZOXAZINE - SULFUR COPOLYMER, METHOD FOR PREPARATION" (Indian Patent Number: 581722).

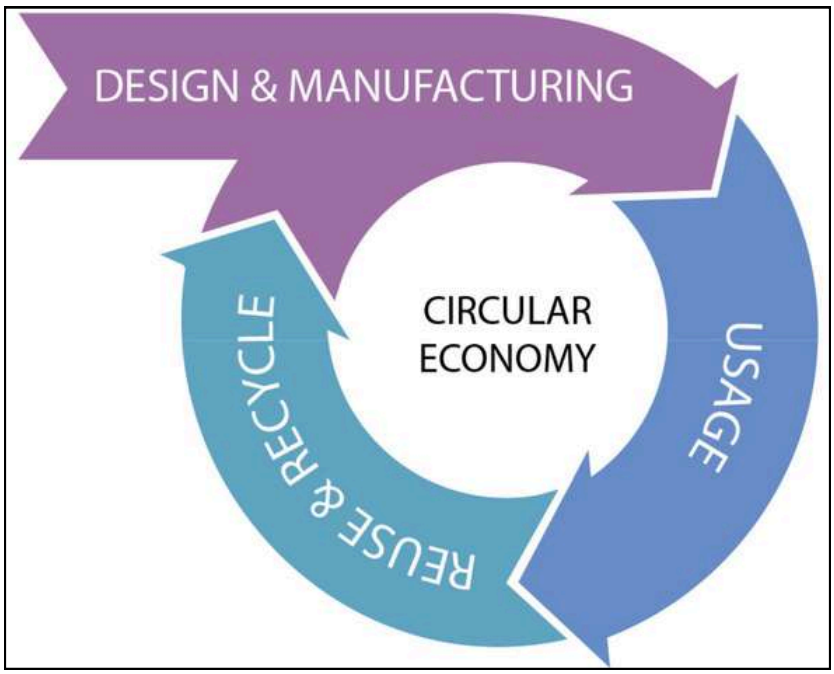
toward designing smarter, more sustainable materials, plastics that can be reused, repaired, and recycled efficiently. One promising approach is "benign-by-design," where materials are engineered from the beginning to minimize environmental impact.

A key concept driving this innovation is dynamic covalent chemistry. Unlike conventional brittle plastics, which are permanently set once formed, materials based on dynamic bonds can break and reform under specific conditions. This allows them to be reshaped, repaired, and recycled without losing performance, effectively extending their lifecycle and reducing waste.

The use of biobased and underutilized waste resources is another critical component of this transition. In this context, cardanol, derived from cashew nutshell liquid (CNSL), offers a sustainable alternative to petroleum-based chemicals. It is a non-edible industrial byproduct generated in large quantities during cashew processing. Cardanol possesses a phenolic structure with a long aliphatic chain, making it highly suitable for polymer synthesis, especially in thermosetting systems like polybenzoxazines. In parallel, elemental sulfur, an abundant byproduct of petroleum refining and natural gas processing, represents another valuable yet underutilized resource. Millions of tons of sulfur are produced annually, often exceeding industrial demand, resulting in large stockpiles. Incorporating sulfur into polymer networks not only provides functional advantages but also helps transform industrial waste into a useful material.

The patented work builds on the idea of developing a benzoxazine-sulfur copolymer synthesized from renewable feedstocks, such as cardanol and cystamine, and waste-derived sulfur. The resulting polymers exhibit dynamic sulfide linkages, enabling recyclability and reprocessability, allowing them to be reshaped and reused, as well as self-healing behavior, where damage can be repaired. The copolymer also demonstrates shape recovery and can function as a debondable adhesive (on-demand glue), enabling easy disassembly in applications where reuse or repair is desired. Such a material design is particularly valuable in advancing a circular materials economy, where commodities are designed to remain in use for as long as possible and then recovered and reused efficiently.

This work demonstrates that plastic sustainability is not a lost cause. By rethinking materials at the molecular level and integrating renewable resources with waste utilization, plastics can transition from a linear "use-and-dispose" model to a circular system. In this sense, recycling becomes more than waste management, it becomes a reversible healing process for both material and the environment.



Patent Reference:

Bimlesh Lochab, "BENZOXAZINE - SULFUR COPOLYMER, METHOD FOR PREPARATION" (Indian Patent Number: 581722).

A Solar-Enabled Charging System for Mobile Phones: Toward a Self-Sustaining Future

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Scientific Profile | Organization Link | Research Lab Page | Factors Press |

Areas of Expertise: Renewable Energy Systems | Energy Harvesting Technologies | Smart Power Management

Mobile phones have become an essential part of modern life. From communication and education to healthcare, navigation, and financial transactions, smartphones play a central role in everyday activities. However, one persistent challenge remains battery life. Despite rapid advancements in mobile technology, users still depend heavily on frequent charging, which can be inconvenient and limiting. This issue becomes more critical in situations where access to electricity is limited, such as during travel, outdoor activities, or emergency conditions. Additionally, increasing energy consumption contributes to environmental concerns, including higher carbon emissions. These challenges highlight the need for innovative, sustainable, and self-sufficient energy solutions in mobile devices.

To address this challenge, we have developed a novel system that integrates renewable energy generation directly into mobile devices. This innovation combines three key components: a transparent solar-enabled glass film on the mobile screen, a solar-enabled fiber-based material forming the phone's structure, and an internal power management system.

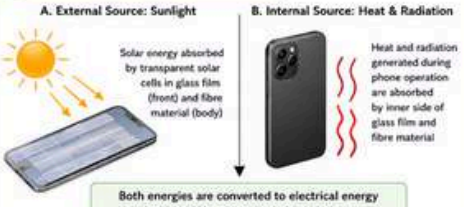
SUPPORTIVE VISUALS FOR STUDY OF SOLAR-ENABLED MOBILE SCREEN

1 SOLAR SCREEN DIMENSIONS AND AREA

Active Area
= 15 cm × 7 cm
= 105 cm²
= 0.0105 m²

This active area is considered for energy generation analysis.

2 DUAL ENERGY HARVESTING CONCEPT

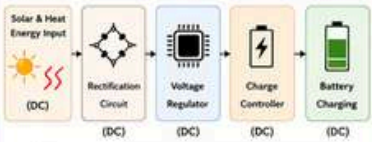


Both energies are converted to electrical energy and managed by power management system to charge the battery.

3 LAYERED STRUCTURE OF SOLAR-ENABLED PHONE

1. Transparent Protective Coating (Anti-scratch, Anti-reflection)
2. Transparent Solar Cells in Glass Film (Front Side)
3. Display Layer (AMOLED/LCD)
4. Touch Sensor Layer
5. Solar-Enabled Fibre Material (Body – Back & Sides)
6. Internal Electronics with Power Management System
7. Battery (Li-ion/Li-polymer)

4 POWER MANAGEMENT SYSTEM ARCHITECTURE



Functions:
- Optimizes voltage and current
- Prevents overcharge, overvoltage and short circuit
- Ensures safe, efficient and continuous charging

5 ENERGY GENERATION ANALYSIS (6 HOURS EXPOSURE)

Condition	Solar Irradiance (W/m²)	Incident Energy in 6 Hours (Wh) A × I × t	Useful Electrical Energy After Conversion & Electronics (Wh) 5% Eff.	8% Eff.	10% Eff.	Equivalent Battery Capacity (19.25 Wh) 5%	8%	10%
Outdoor Sunlight (Direct Sun)	700	44.1	1.76	2.82	3.53	9.16%	14.66%	18.33%
Indoor (Normal Light)	100	6.3	0.25	0.40	0.50	1.31%	2.09%	2.62%
Indoor (Bright Window)	200	12.6	0.50	0.81	1.00	2.62%	4.19%	5.24%

Outdoor sunlight for 6 hours can generate ~1.8 to 3.5 Wh (depending on efficiency), which is ~9% to ~18% of a typical 5000 mAh battery.

6 USAGE TIME SUPPORTED (OUTDOOR SUNLIGHT, 6 HOURS)

Solar Film Efficiency	Energy Generated (Wh)	Additional Usage Time Provided: Light Use (1.5 W)	Normal Use (2.5 W)	Heavy Use (4.0 W)
5%	1.76	1 h 11 min	42 min	26 min
8%	2.82	1 h 53 min	1 h 08 min	42 min
10%	3.53	2 h 21 min	1 h 25 min	53 min

Solar screen can extend smartphone usage by ~40 to 85 minutes (normal use) in 6 hours of good sunlight.

7 INDOOR USAGE TIME (6 HOURS)

Normal Indoor (100 W/m²) Efficiency	Energy Generated (Wh)	Usage Time Provided: Light Use (1.5 W)	Normal Use (2.5 W)	Heavy Use (4.0 W)
5%	0.25	10 min	6 min	4 min
8%	0.40	16 min	10 min	6 min
10%	0.50	20 min	12 min	8 min

Bright Indoor (200 W/m²) Efficiency	Energy Generated (Wh)	Usage Time Provided: Light Use (1.5 W)	Normal Use (2.5 W)	Heavy Use (4.0 W)
5%	0.50	20 min	12 min	8 min
8%	0.81	32 min	19 min	12 min
10%	1.00	40 min	24 min	15 min

Indoor light helps in trickle charging and slowing battery drain, not for full power sustainment.

COMPARISON: CONVENTIONAL vs SOLAR-ENABLED SMARTPHONE

Feature	Conventional Smartphone	Solar-Enabled Smartphone (This Work)
Charging Source	Grid Electricity	Sunlight + Heat (Dual Source)
Charging Frequency	Daily / Frequent	Reduced Significantly
Dependence on Outlet	High	Low
Energy Sustainability	Low	High (Renewable)
Battery Extension	No	Yes (Up to ~18% in 6 h sunlight)
Ideal Use	Indoor / Limited	Outdoor, Travel, Emergency, Low Electricity Areas

KEY TAKEAWAY

- A 15 cm × 7 cm transparent solar screen can generate ~1.8 to 3.5 Wh in 6 hours of outdoor sunlight.
- This energy can extend smartphone usage by ~1 to 2.3 hours (light use) or ~40 to 85 minutes (normal use).
- Indoor light provides small energy for trickle charging and slowing battery drain.
- Combining solar screen with solar body and heat recovery enhances overall sustainability and performance.

Future Impact
- Reduced charging frequency
- Energy independence in critical situations
- Eco-friendly & sustainable technology
- Supports green mobile ecosystem

Note: Actual performance may vary based on location, weather, orientation, season, device usage pattern, temperature, and efficiency of solar cells & electronics.

Patent Reference:

S. S. Pund, A Solar-Enabled Charging System for Mobile Phones, Indian Patent Number: 580340.

Together, these elements allow the device to generate electrical energy from two complementary sources solar energy from sunlight (external source) and heat and radiation produced during device operation (internal source). This dual-source energy approach enhances overall efficiency and reliability compared to conventional single-source systems, offering a promising pathway toward self-sustaining mobile technologies.

The working principle of the system is based on dual energy harvesting. The outer surface of the mobile phone, including the screen and body, is integrated with embedded solar cells that capture sunlight and convert it into electrical energy. Simultaneously, the inner side of the glass film and fiber-based body harnesses heat and radiation generated during regular phone usage. These two energy sources are then processed through an internal power management system comprising rectification circuits, voltage regulators, and charge controllers. This system ensures that the harvested energy is converted into a stable and usable form, enabling safe and efficient charging of the device's battery. Through this continuous process, the phone can generate and utilize energy during normal operation and sunlight exposure, thereby reducing dependence on conventional external charging methods.

This system stands out due to its integrated and hybrid approach to energy generation. Unlike conventional solar chargers or power banks that rely solely on external sunlight, this innovation utilizes both external solar energy and internally generated heat, effectively converting waste heat into useful electrical energy. The energy-harvesting mechanism is seamlessly integrated across the entire body of the device, enabling continuous operation without the need for additional accessories. By combining principles from solar energy engineering, thermoelectric energy conversion, and smart power management systems, this technology represents a compact and efficient hybrid renewable energy solution embedded directly within the mobile device.

To evaluate the feasibility of this system, a typical smartphone screen size of 15 cm × 7 cm was considered. Under average outdoor sunlight conditions, with approximately six hours of exposure, the system can generate around 1.7 to 3.5 watt-hours (Wh) of electrical energy. This output corresponds to approximately 9% to 18% of a standard 5000 mAh smartphone battery capacity. In practical terms, this additional energy can extend mobile usage by up to two hours under light usage conditions and approximately 40 to 85 minutes under normal usage. Even under indoor conditions, although the energy generated is lower, it remains useful for trickle charging, helping to slow down battery discharge when the device is not in heavy use. While this system may not fully replace conventional charging methods, it can significantly reduce charging frequency and enhance overall battery efficiency.

The solar-enabled charging system offers several practical benefits, making it a promising solution for modern mobile technology. By reducing dependence on conventional charging sources, users can rely less on electrical outlets, particularly during daytime use. The system also promotes environmental sustainability by utilizing renewable energy, thereby lowering reliance on grid electricity and reducing carbon emissions. Continuous energy generation helps maintain battery levels, improving overall efficiency and extending battery life. Additionally, the technology proves especially useful in remote locations or emergency situations where access to electricity is limited. Over time, reduced electricity usage can also contribute to cost savings.

From an engineering perspective, this system represents a significant step toward self-sustaining mobile devices. While the current energy output provides supplementary support, future advancements in transparent solar cell efficiency, thermoelectric energy conversion, and smart power management systems have the potential to enhance performance further. Expanding energy-harvesting surfaces, such as integrating solar and thermal elements into the back panel or edges of the device, could also increase overall energy generation capacity.

In conclusion, this solar-enabled charging system introduces an innovative hybrid energy-harvesting approach that addresses the persistent challenge of battery dependency in smartphones. By combining solar energy with heat recovery, it enhances battery performance, reduces charging frequency, and supports sustainable energy use. Although it does not entirely replace traditional charging methods, it marks an important step toward the development of self-sustaining, energy-efficient mobile devices, contributing to a greener and more connected future.

Patent Reference:

S. S. Pund, A Solar-Enabled Charging System for Mobile Phones, Indian Patent Number: 580340.

Sustainable Piezocatalyst for Clean and Green Hydrogen Production

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Scientific Profile | Organization Link | Research Lab Page | Factors Press

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Scientific Profile | Organization Link | Research Lab Page | Factors Press

Areas of Expertise: Photocatalysis | Electrocatalysis | Energy generation | Nano-Biomedicine

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Scientific Profile | Organization Link | Research Lab Page | Factors Press

Areas of Expertise: Biophotocatalysis | Energy generation | Nano-Biomedicine

The world is currently facing a severe energy crisis driven by the excessive and rapid consumption and depletion of non-renewable fossil resources and the ever-increasing demand for energy due to industrialization, population growth, and urbanization. Conventional energy sources such as coal, oil, and natural gas are not only limited but also major contributors to environmental pollution and climate change. Their excessive use releases large amounts of greenhouse gases, leading to global warming, ecological imbalance, and serious health hazards.

Green hydrogen (H2) fuel has emerged as a key solution to meet the world's growing energy demand while reducing dependence on fossil and minimizing environmental pollution. Unlike conventional H2 production methods that rely on carbon-intensive processes, green H2 is generated using renewable energy sources, making it clean, sustainable, and environmentally friendly. As the global community moves toward carbon neutrality and sustainable development, there is an urgent need for efficient and cost-effective technologies that can produce H2 without harmful emissions. However, current H2 production technologies often suffer from low efficiency, high energy consumption, and complex operational requirements, limiting their industrialization.

Our invention introduces a novel and sustainable approach towards sustainable H2 production using a gamma-iron oxyhydroxide (γ-FeOOH) nucleated sodium niobate (NaNbO3) binary piezophotocatalyst. This advanced material is designed to overcome the limitations of traditional catalysts by utilizing both solar energy and mechanical energy (vibrations or ultrasonic waves), to drive chemical reactions. This dual-energy harnessing strategy significantly enhances the efficiency of H2 production and offers a more practical and sustainable solution. In simple terms, when the piezocatalyst is exposed to sunlight and mechanical stress, it generates tiny charged particles known as electrons and hol-

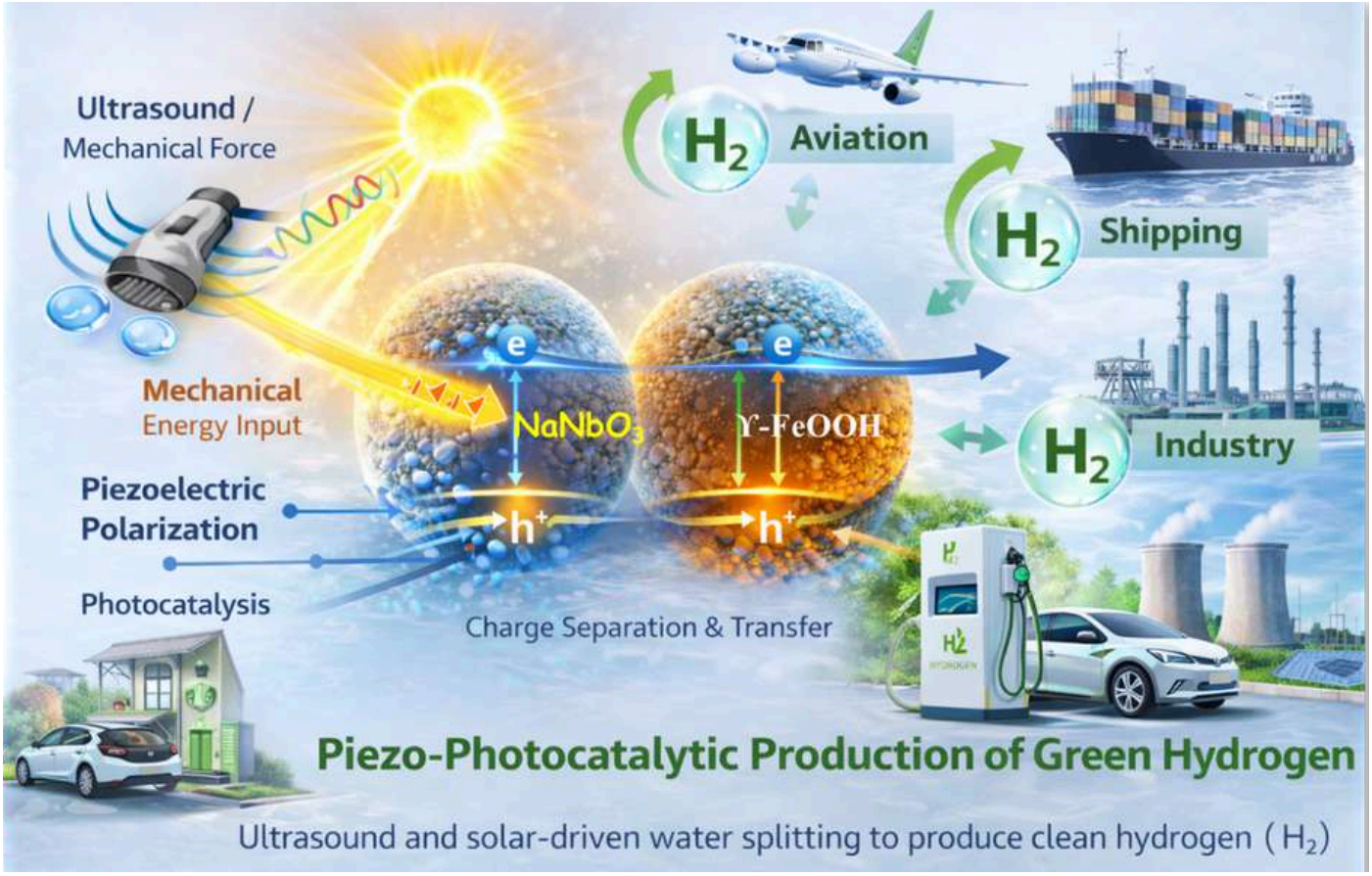
Patent Reference:

Parida, K., Mansingh, S., Priyadarshini, N. (2026). Gamma-Iron oxyhydroxide (Y-FeOOH) nucleated Sodium niobate (NaNbO3) binary piezocatalyst and method for synthesis thereof. Indian Patent No. 581681

es. These charges are essential for initiating chemical process, particularly the splitting of water into H2 and O2. One of the major challenges in conventional systems is that these charges tend to recombine quickly, resulting in energy loss and reduced efficiency. However, in this innovation, the combination of γ-FeOOH and NaNbO3 forms a unique heterostructure that promotes efficient separation and movement of these charges. Additionally, the presence of oxygen vacancies in the material creates extra active sites and improves charge transfer, further enhancing catalytic performance.

The uniqueness of this approach lies in its piezophotocatalytic mechanism, where both light and mechanical energy work together to improve efficiency. The interaction between γ-FeOOH nanorods and NaNbO3 microcubes generates an internal electric field that facilitates effective charge separation, resulting improved H2 production compared to conventional photocatalysts. Furthermore, the synthesis process of the material is simple, low-cost, and environmentally friendly, involving hydrothermal and in-situ co-precipitation methods under mild conditions. The use of water as a solvent and the absence of toxic chemicals make the process sustainable and suitable for large-scale applications.

The potential benefits of this innovation are wide-ranging. In the energy sector, it provides a clean and efficient pathway for green H2 production, which can be used as a sustainable fuel for transportation, power generation, and industrial processes. In addition, the catalyst can also be applied for environmental remediation.. By reducing reliance on fossil fuels and minimizing pollution, this technology can contribute to improved environmental quality and public health.



Patent Reference:

Parida, K., Mansingh, S., Priyadarshini, N. (2026). Gamma-Iron oxyhydroxide (Y-FeOOH) nucleated Sodium niobate (NaNbO3) binary piezocatalyst and method for synthesis thereof. Indian Patent No. 581681

A Biosensor for Detection of Dopamine

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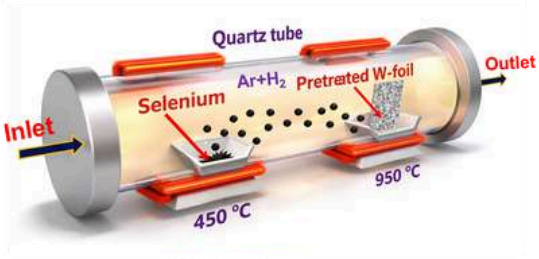
| Scientific Profile | | Organization Link | | Research Lab Page | | *Factors Press* |

Areas of Expertise: 2D Nanomaterials | Materials for Sensors | Materials for Optoelectronic Devices | Materials for Energy Devices

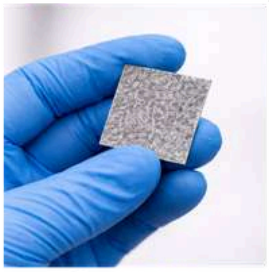
Scientific inventions in biosensing are important in enhancing early detection and monitoring of diseases. Dopamine is a neurotransmitter, which is an important biomolecule in the human body, and plays a vital role in the work of brain, nervous system, and cardiovascular system. It triggers feeling of satisfaction, motivation, cognition and mood. The abnormal dopamine levels are associated with severe neurological conditions, such as Parkinson, Alzheimer, Huntington, and Schizophrenia. Due to its clinical significance, the sensitive and accurate detection of dopamine is very important. Conventional methods of detecting dopamine involve electrochemical, fluorescence, chromatography, and colorimetry techniques. These methods may work well, but most of them need complicated instrumentation, more time to process, or more expensive laboratory equipment. Consequently, the necessity has increased to have easy, quick and extremely sensitive biosensors that are capable of detecting ultra traces of dopamine.

Our invention is a novel material-based biosensor, which can detect dopamine at very low concentrations using Surface-Enhanced Raman Scattering (SERS) technique. The SERS technique is based on interaction between substrate and analyte. Our sensor is based on a thin film of Tungsten Diselenide (WSe2) that is specially prepared on a tungsten foil substrate using Chemical Vapor Deposition (CVD) technique. The WSe2 grows as particulate nanostructures on tungsten foil, which provide good platform for dopamine to attach with its surface. The interaction of dopamine molecules with the surface of WSe2 produces powerful Raman signals, which allows more precise and reliable detection. One of the main specialties of the design is its high sensitivity. The biosensor can detect dopamine up to extremely low concentrations as

Step 1- Substrate synthesis



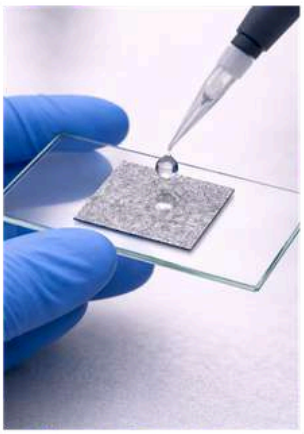
CVD setup



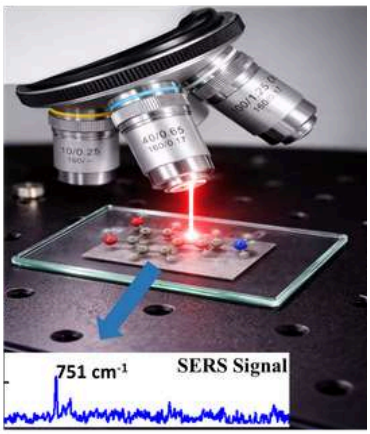
WSe_2/W- foil

Step 2- Dopamine detection by SERS measurement

Dopamine solution



Drop casting of the dopamine solution on WSe_2/W-foil



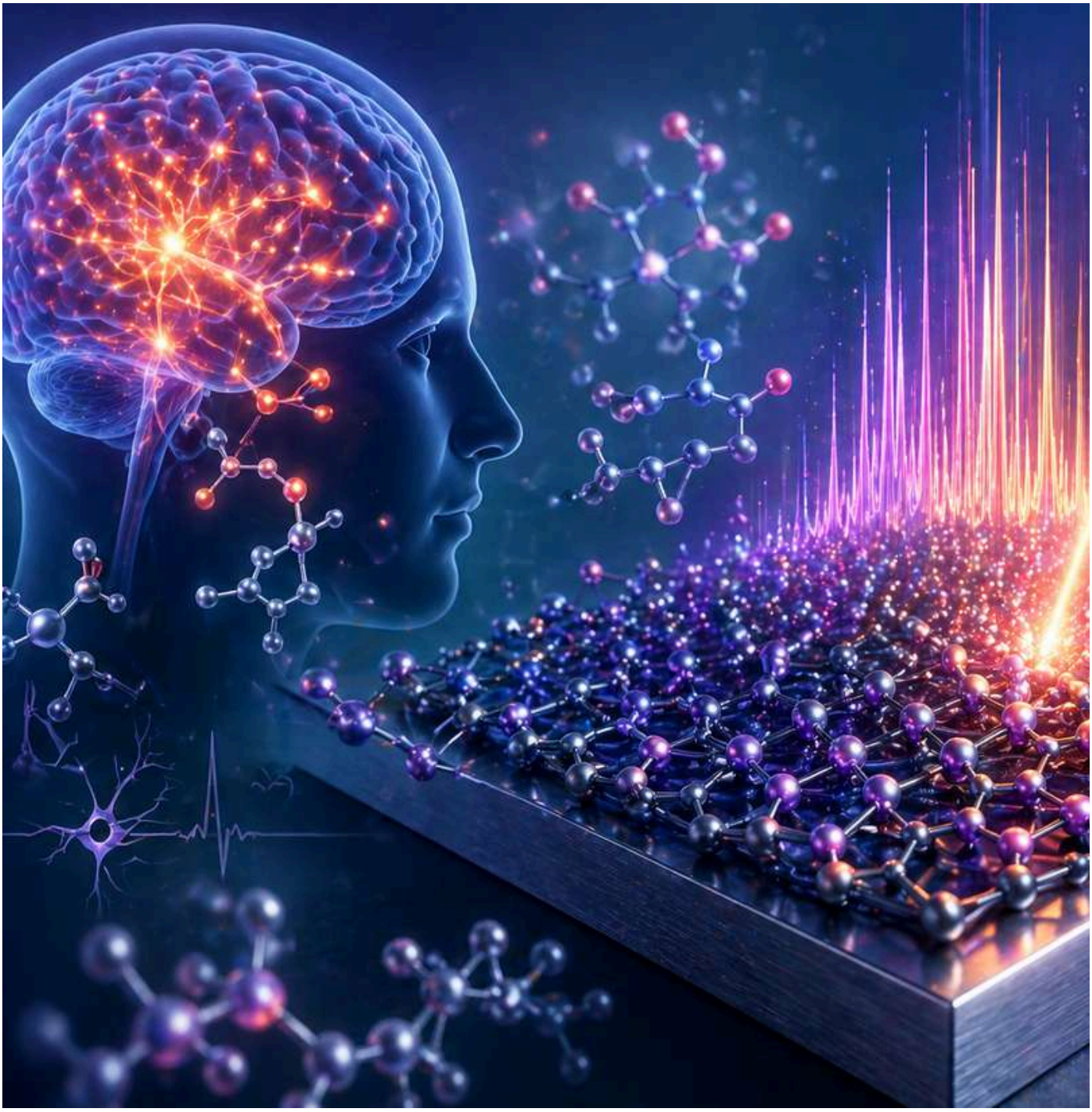
SERS measurement

Patent Reference:

A.K. Mishra and P. Jangra, A biosensor for detection of an analyte and a method of fabrication thereof, Indian Patent Number- 580609, Issued Date- 13-02-2026.

low as 10-7 M (hundred nanomolar level). This sensitivity allows the measurement of small variations in dopamine levels, which is critical in the early diagnosis as well as monitoring of neurological disorders.

Our invention employs a comparatively simple process of fabrication of WSe2 based SERS biosensor, which is scalable and repeatable. The possible use of this biosensor is not limited to detection of dopamine only, but also can be used for detection of other biomolecules like vitamin B12, bilirubin etc. As it advances, it may find application in medical diagnostics, biosensing applications, pharmaceutical analysis, and neurological studies. This technology has the potential to revolutionize the next-generation biosensing platform using advanced nanomaterials and Raman spectroscopy that can be utilized in healthcare and biomedical research.



Patent Reference:

A.K. Mishra and P. Jangra, A biosensor for detection of an analyte and a method of fabrication thereof, Indian Patent Number- 580609, Issued Date- 13-02-2026.

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| Scientific Profile | | Organization Link | | Factors Press |

From Academia to Biotech: A Scientist's Journey into Innovation

To begin with, we would be delighted if you could briefly introduce yourself and share a little about your current role at PopVax.

- I am Bartika Ghoshal, a senior scientist working at PopVax Pvt. Ltd., where I work in the Immunology Team of the R&D department. My journey into science began with a degree in Zoology, which sparked my interest in genetics and molecular biology. After completing my master's degree, I pursued a Ph.D. focused on microRNA and its role in cell biology. During this time, I investigated the mechanism of microRNA transfer between mammalian cells by Extracellular Vesicles. This experience led me to focus on the use of Extracellular Vesicles for drug delivery. After exploring diverse areas from Zoology to drug delivery I have reached a stage in my career where I want to apply my expertise in drug delivery to translational research and development.

You built a strong academic research career before moving into industry. What inspired your transition from academia to biotech?

- I had always imagined a career in academia. However, towards the end of my Ph.D., the COVID-19 pandemic disrupted that path and reshaped my perspective. As companies like Moderna, Pfizer, Bharat Biotech, to name a few, came into the global spotlight; I began to truly understand how research moves from the bench to the bedside. This realization motivated me to develop expertise in using Extracellular Vesicles (EVs) as drug delivery systems. I soon had the opportunity to work at IISc on an mRNA vaccine program as well drug delivery using immune cell-EVs, and since then, there has been no looking back. Being part of impactful translational research redirected my passion toward the biotech industry.

How different is scientific work in a biotechnology company compared with academic research?

- In academia, research is primarily driven by curiosity and the pursuit of fundamental questions, without being constrained by a specific organizational vision. In contrast, research in the biotech industry is tailored according to the company's vision and priorities with basic scientific ideas being shaped towards translational outcomes such as drug discovery and development for specific disease conditions. Another key difference lies in how work is structured. Academic research is typically more independent and flexible, whereas industry research involves close collaboration across multiple teams. This means that the work has to be done in a more collaborative, coordinated manner within strict timelines.

Your academic work involved extracellular vesicles, mRNA delivery, and immune engineering. How has your research background helped you in your current industry role?

- I think the fact that my skillsets partly align with drug delivery paved the way for my transition into industry. My Ph.D. provided a strong foundation in cell biology and biochemistry, while my postdoctoral work helped me develop a translational perspective on fundamental scientific problems, along with the ability to troubleshoot complex research questions. During this phase, I learnt the basics of Immunology and mRNA vaccine biology, which also helped me move into my current role. Understanding the full journey--from mRNA as the starting material to the final product--helped shape my transition into the vaccine or therapeutics-focused industry.

What motivated you to join a company like PopVax at this stage of your career?

- I was not ready to give up on actively doing innovative research when I was deciding to transition to industry. Initially, I had limited understanding of how research in biotech companies operates, which made the decision feel intimidating. When I started to learn and research about the different R&D biotech companies in India, I realized that some companies are involved in innovative translational research. This understanding reinforced my decision to make the transition. Finally, when I learnt that PopVax is doing innovative R&D research on mRNA vaccines and therapeutics, I was excited to apply. It assured me that this path would keep me closely connected to science, with continuous opportunities for growth rather than a monotonous career trajectory.

PopVax is working at the intersection of vaccines, cancer immunotherapy, and AI-driven biotechnology. What excites you most about being part of this kind of innovation ecosystem?

- The answer lies in the question itself. What excites the researcher in me the most is the opportunity to continuously learn and work at the intersection of compelling scientific questions. While the breadth of knowledge required is wide and constantly evolving, the learning curve and growth have been both rapid and substantial. This experience has helped me develop a more interdisciplinary approach to scientific problem solving and has kept me deeply engaged with ongoing research.

What has been the most surprising or rewarding part of your journey after moving into industry?

- I had always held a different perception of industry jobs, especially in India, and assumed they would be monotonous, involving routine execution of assays. Despite that, I decided to make the shift and I am glad that I did not let my preconceived notion guide me. In reality, industry research is definitely not monotonous. Every day is different and one has immense scope of learning. This has been one of the most rewarding aspects of my transition, as I have been able to acquire new knowledge in a relatively short span of time and continue to build on it. The experience has also given me a broader perspective on emerging drug delivery strategies and innovations being pursued globally, which has been both enriching and motivating.

Were there any challenges or uncertainties when you moved from academia to industry? How did you navigate that transition, both professionally and personally?

- Yes, unfortunately there is still limited awareness about how biotech companies operate in India, how they are funded, what the typical career structures or pay scales look like. As a result, transitioning into industry initially felt like stepping into unknown waters. However, during my postdoctoral period, I did have the opportunity to network, attend seminars and conferences and learn about how the Indian biotech ecosystem functions. These interactions helped me understand differentcompanies, their areas of focus, and their long-term goals, which gave me the confidence to apply for industry roles. On a personal level, it took me some time to come to terms with this transition. However, having made the transition, I can say that my growth has not stunted, instead, it has expanded and I have developed new skills along my career journey.

Many young researchers worry that moving to industry means "leaving science." Based on your experience, how true or untrue is that?

- I was also among the researchers who believed that moving to industry meant, "leaving science." However, my experience has shown otherwise. After joining, it took me some time to adjust to how an industry setup functions, but I gradually realized that it can be just as intellectually stimulating as academia. It offers the opportunity to engage in innovative translational research and to continuously learn about new developments across multiple areas. While academia often involves deep, focused exploration of a specific topic, industry can offer exposure to a broader range of scientific problems, depending upon the goals and priorities of the company. This has allowed me to expand my understanding across disciplines, and the growth in knowledge has been anything but linear.

What kinds of skills are most important for scientists who want to build a successful career in biotech or translational research?

- A scientist can acquire hard skills at any stage of their career- we are trained that way. However, I feel

certain soft skills often play a defining role in shaping a career in the biotech industry. For instance, time management, communication skills, taking ownership of the task assigned to you, accountability are very important in the industry setting. In addition, one has to be flexible and open to learning, as translational research often requires adapting quickly to evolving needs and priorities.

How do you see the future of biotechnology and vaccine innovation evolving in India over the next 5–10 years?

- Post-COVID, the Indian biotech sector has seen a boom in start-ups and companies, which are trying to do innovative and cutting-edge research. I believe that over the next 5-10 years, India will make significant strides in mRNA, DNA vaccine platforms, gene therapy, CAR-T therapy and AI- driven drug discovery. With the support of emerging funding sources and national initiatives, more start-ups will thrive, improving both research efficiency and clinical outcomes. Furthermore, I believe the gap between academia and industry will continue to narrow, with stronger collaborations between the two. This will not only enhance knowledge exchange but also create greater awareness and smoother pathways for researchers transitioning into industry.

What advice would you give to students, PhD scholars, and postdoctoral researchers who are considering a transition from academia to industry?

- From my personal experience and interactions, I have observed that most researchers tend to transition from academia to industry out of frustration and disappointment. My suggestion would be whatever the case, be it a conscious choice or a difficult decision, one must conduct extensive research about the companies they wish to apply to. This will help them align their skillsets with the company goals and expectations. The resume must be carefully structured to highlight relevant skills and research interests. Additionally, networking very crucial in gaining a clear understanding of a company's vision to ensure that it aligns with one's own interests before making the transition. Finally, trust the process, the transition will not be smooth in most cases and will take time but the experience will be valuable contributing significantly to both personal and professional growth.

| OBITUARY |

Madhav Gadgil

THE SCIENTIST WHO GAVE NATURE A VOICE

(1942–2026)

India lost one of its most respected environmental scientists on 7 January 2026, when Madhav Gadgil passed away in Pune at the age of 83. For more than five decades, he worked to understand India's forests, wildlife, and people and to protect them for future generations.

Born on 24 May 1942 in Pune, Gadgil grew up in a family that valued learning. He studied biology at Fergusson College in Pune, completed his master's degree in zoology from the University of Mumbai, and later went to Harvard University, where he earned his PhD in 1969. At Harvard, he was influenced by leading ecologists and developed a strong interest in mathematical ecology and animal behavior. After a short teaching period in the United States, Gadgil returned to India in 1971. He joined the Indian Institute of Science (IISc), Bengaluru, where he would spend more than thirty years building modern ecological research in the country. He founded the Centre for Ecological Sciences at IISc a pioneering institution that trained generations of Indian ecologists. He also helped establish the Centre for Theoretical Studies.

Gadgil believed that ecology was not just about forests and animals. It was also about people. He introduced scientific, quantitative methods to study ecosystems in India and emphasized that humans are an important part of nature, not separate from it. His work connected science with real-life issues such as forest management, biodiversity conservation, and sustainable development.

One of his most important achievements was helping India establish its first biosphere reserve the Nilgiri Biosphere Reserve in 1986. His research in the 1980s played a major role in identifying the ecological importance of the Nilgiri region. This was a turning point in India's conservation history. In 2010, the Government of India appointed him chairman of the Western Ghats Ecology Expert Panel (WGEEP), widely known as the Gadgil Commission. The panel studied the fragile Western Ghats mountain range and recommended that large parts of it be declared ecologically sensitive. His 2011 report sparked national debate. Environmentalists supported his strong conservation measures, while some state governments and groups opposed them. Even though not all recommendations were accepted, the report changed the way India discussed environmental protection.

Gadgil also played an important role in shaping the Biological Diversity Act of 2002 and promoted the idea of People's Biodiversity Registers, encouraging local communities to document and protect their natural resources. He believed that conservation should involve villagers, farmers, and indigenous communities.

Throughout his career, Gadgil published over 250 scientific papers and several influential books. His book This Fissured Land (co-authored with Ramachandra Guha) explored India's ecological history. He wrote in both English and Marathi, making science accessible to ordinary people. He also wrote columns for newspapers like The Hindu and Sakal, sharing stories about nature with the wider public.

His contributions were recognized globally. He received the Padma Shri in 1981 and the Padma Bhushan in 2006 from the Government of India. Internationally, he was honored with the Volvo Environment Prize, the Tyler Prize for Environmental Achievement, and in 2024, the prestigious Champions of the Earth Award from the United Nations.
Beyond science, Gadgil was known for his simplicity and integrity. As a young man, he was also an athlete, holding high jump records during his college days. He was married to noted meteorologist Sulochana Gadgil, who passed away in 2025. He is survived by his children.
Madhav Gadgil's legacy lives on in India's forests, in its environmental laws, and in the many students he mentored. He showed that science can guide society toward wiser decisions. More than a researcher, he was a bridge between knowledge and action a scientist who gave nature a strong and thoughtful voice.
India remembers him not only as an ecologist, but as a guardian of its natural heritage.

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

SCIENCE NEWS & OPPORTUNITIES

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

James Watson – April 6

01

April marks the birth of James Watson, whose work helped reveal the structure of DNA the blueprint of life. DNA carries the instructions that determine how living organisms grow, function, and reproduce. Understanding its double-helix structure transformed biology, opening the door to modern genetics, biotechnology, and medicine. From diagnosing genetic diseases to advancing genome editing, this discovery continues to shape scientific progress. By exploring the code of life, Watson's contribution has helped humanity better understand itself and improve health and agriculture for the future.

World Health Day – April 7

02

April 7, World Health Day, reminds us that good health is the foundation of a strong and thriving society. It highlights the importance of accessible healthcare, disease prevention, and overall well-being for people across the world. From fighting infectious diseases to improving mental health, science and medicine play a critical role in shaping healthier lives. However, challenges such as inequality, emerging diseases, and lifestyle-related disorders continue to grow. Strengthening healthcare systems, promoting awareness, and encouraging healthy habits are essential steps toward a healthier future for all.

World Homeopathy Day – April 10

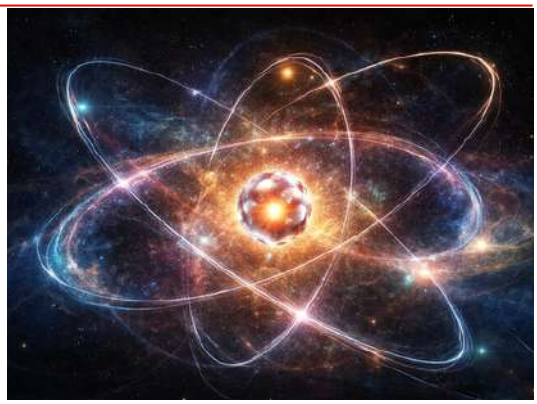
03

April 10, World Homeopathy Day, recognizes an alternative approach to medicine that emphasizes natural healing and individualized care. Homeopathy is based on the idea that substances causing symptoms in healthy individuals can, in small doses, help treat similar symptoms in patients. It focuses on stimulating the body's natural ability to heal itself. While widely practiced in many parts of the world, it also continues to be discussed and evaluated within the broader scientific and medical community.

World Quantum Day – April 14

04

April 14, World Quantum Day, celebrates the fascinating science that explains how the smallest parts of our universe behave. Quantum physics reveals that particles can exist in multiple states and behave in unexpected ways, challenging our everyday understanding of reality. This field forms the foundation of many modern technologies, including semiconductors, lasers, and emerging quantum computers. As research advances, quantum science holds the promise of revolutionizing computing, communication, and materials. By exploring the unseen world of atoms and particles, we unlock possibilities that can transform the future.



Rita Levi-Montalcini – April 22.

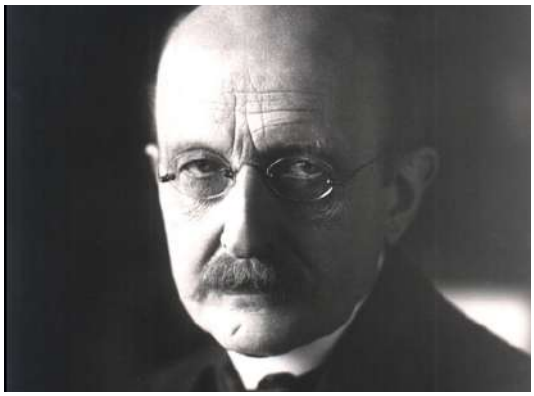
05 April 22 honors the birth of Rita Levi-Montalcini, whose discovery transformed our understanding of the human brain. She identified Nerve Growth Factor (NGF), a molecule essential for the growth, survival, and communication of nerve cells. This breakthrough revealed how the nervous system develops and adapts, offering insights into brain function and repair. Her work has become fundamental in studying neurological disorders and injuries. By uncovering how our nervous system is built and maintained, her contribution continues to inspire advances in medicine and neuroscience.

Earth Day – April 22

06 April 22, Earth Day, reminds us that our planet is a shared home that requires care, responsibility, and collective action. It highlights the importance of protecting natural resources, reducing pollution, and addressing climate change. Forests, oceans, and ecosystems support life, regulate climate, and provide essential resources. However, human activities are placing increasing pressure on these systems. Sustainable practices, conservation efforts, and global cooperation are key to preserving Earth's balance. By taking action today, we can ensure a healthier environment and a sustainable future for generations to come.

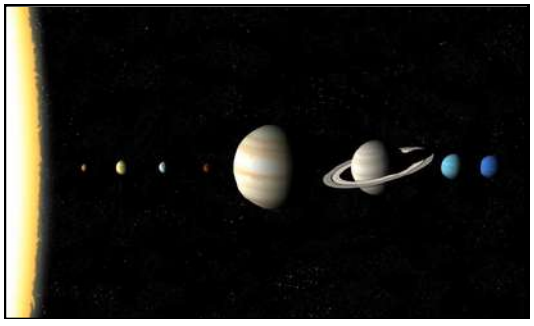
Max Planck – April 23

07 April 23 celebrates the birth of Max Planck, the pioneer who changed our understanding of energy and the universe. He discovered that energy exists in tiny packets called quanta, rather than flowing continuously. This simple yet revolutionary idea gave rise to quantum physics, a field that explains how matter and energy behave at the smallest scales. Today, Planck's work underpins technologies such as lasers, semiconductors, and modern electronics. By redefining the nature of energy, his contribution continues to influence science, innovation, and the technologies that power our daily lives.



Planetary Alignment – April 2026

08 April 2026 brings a rare planetary alignment, offering a stunning view of multiple planets appearing in a line across the sky. Such events occur when planets orbit the Sun in positions that make them visible together from Earth. While they are not perfectly aligned in space, they create the illusion of a straight line from our perspective. These alignments provide valuable opportunities for astronomers to observe planetary motion and inspire curiosity about our solar system.



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.

| SCIENCE YET TO BE DISCOVERED |

PARP14 AS THE EMERGING ARCHITECT OF CELLULAR SIGNALLING AND A NEW PLAYER IN ADP-RIBOSYLATION WITH PROFOUND TRANSLATIONAL POTENTIAL

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| Scientific Profile |
| Organization Link |
| Factors Press |
Areas of Expertise: ADP-ribosylation | PARP Biology | DNA Repair | Cellular Ca^{2+} Signalling | Prostate Cancer Signalling Pathways

My research journey has been shaped by a deep interest in understanding how dynamic molecular signals govern cellular fate under stress and disease conditions. My postdoctoral journey at the University of Oxford, encompassing two successive appointments, immersed me in the fascinating realms of intracellular Ca2+ homeostasis and ADP-ribosylation biology an experience that profoundly influenced my scientific path and continues to inspire my research today. My work focuses on understanding the dynamic role of ADP-ribosylation signalling in regulating key cellular processes, particularly in the context of DNA repair, cancer biology, and immune responses. At the molecular level, I am especially interested in how Ca2+ dependent spatio-temporal regulation of ADP-ribosylation shapes cellular decision-making under conditions such as genomic instability, infection, and oncogenic transformation.

The past several decades has witnessed remarkable progress in understanding post-translational modifications as key regulators of cellular physiology. Among these, ADP-ribosylation has emerged as a highly dynamic and versatile signalling mechanism, influencing processes ranging from DNA repair to immune regulation. While early research predominantly focused on poly (ADP-ribose) polymerases such as PARP1, recent advances have brought mono-ADP-ribosyl transferases, particularly PARP14, into sharp focus. PARP14 represents a fascinating convergence of enzymatic activity and signalling complexity, as demonstrated in our recent work. Unlike classical PARPs that primarily catalyse poly-ADP-ribosylation, PARP14 functions predominantly as a mono-ADP-ribosyl transferase. This distinction is not only biochemical it reinforces a fundamentally different mode of cellular regulation. PARP14 integrates catalytic activity with multiple macrodomains, enabling it to both write and read ADP-ribose marks, thereby orchestrating highly context-dependent signalling networks.

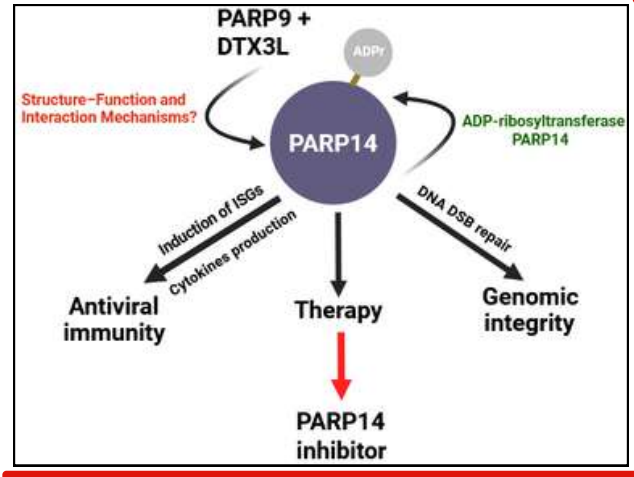
A key aspect of our recent work has been to further elucidate the functional significance of PARP-catalysed ADP-ribosylation in cellular signalling. While ADP-ribosylation is now widely recognized as a critical regulator of diverse biological pathways, PARP-dependent mono-ADP-ribosylation remained relatively underexplored for a long time due to the lack of sensitive detection methods. By employing an improved antibody-based approach, we were able to visualize interferon (IFN)-induced ADP-ribosylation and identify PARP14 as a major enzyme responsible for this modification. Intriguingly, this signalling is reversed by the macrodomain of SARS-CoV-2 (Mac1), suggesting a potential mechanism through which viral proteins counteract host antiviral ADP-ribosylation responses. Furthermore, our findings reveal an important regulatory axis involving PARP9 and its binding partner, the E3 ubiquitinligase DTX3L, which together modulate PARP14 activity through protein–protein interactions as well as through the hydrolytic function of the PARP9 macrodomain. Notably, we also provide the first visualization of ADP-ribosylation-dependent ubiquitylation in the interferon response, revealing a previously unrecognized layer of crosstalk between these two critical post-translational modifications. These findings not only expand our understanding of interferon-driven signalling networks but also shed light on how pathogens may evade host defence mechanisms. One of the most compelling aspects of PARP14 biology lies in its role in immune regulation. It acts as a critical modulator of cytokine signalling pathways, particularly through its interaction with transcription factors such as STAT6. By fine-tuning gene expression programs associated with inflammation and immune polariza-

PARP14 AS THE EMERGING ARCHITECT OF CELLULAR SIGNALLING AND A NEW PLAYER IN ADP-RIBOSYLATION WITH PROFOUND TRANSLATIONAL POTENTIAL

tion, PARP14 contributes to the balance between protective immunity and pathological responses, positioning it at the intersection of cancer, infection, and inflammatory diseases. Beyond immunity, emerging evidence highlights the involvement of PARP14 in DNA damage responses and genome stability. Although traditionally overshadowed by PARP1 and PARP2 in this domain, PARP14 is now increasingly recognized as a contributor to repair pathway choice and replication stress responses. Its ability to modulate protein–protein interactions through ADP-ribosylation introduces an additional regulatory layer that is only beginning to be appreciated.

From a translational perspective, PARP14 represents a promising yet underexplored therapeutic target. The clinical success of PARP inhibitors in oncology has demonstrated the power of targeting ADP-ribosylation pathways. However, most current inhibitors lack specificity for mono-ADP-ribosyl transferases. The development of selective PARP14 inhibitors could therefore open new avenues for treating cancers with dysregulated immune microenvironments, as well as diseases characterized by aberrant cytokine signalling. Equally exciting is the potential integration of PARP14 biology with emerging therapeutic strategies. Nanotechnology-driven drug delivery systems may enable precise targeting of ADP-ribosylation pathways in specific tissues or cell types. In parallel, the intersection of PARP14 signalling with metabolic and epigenetic networks suggests opportunities for combination therapies that exploit multiple vulnerabilities within diseased cells.

Despite these advances, several important questions remain. What determines substrate specificity in PARP14-mediated ADP-ribosylation? How is its activity dynamically regulated across different cellular contexts? And crucially, how can we translate mechanistic insights into clinically viable interventions without disrupting physiological homeostasis? Addressing these challenges will require interdisciplinary efforts that bridge structural biology, chemical biology, and systems-level analyses. In this evolving paradigm, PARP14 stands as a compelling example of how expanding our understanding of so-called “non-canonical” signalling pathways can reshape fundamental biology and inspire innovative therapeutic strategies.



In conclusion, the study of PARP14 and mono-ADP-ribosylation is rapidly evolving from a niche area into a central theme in modern biomedical research. By unravelling its complex regulatory networks, we not only deepen our understanding of cellular signalling but also pave the way for next-generation interventions in DNA repair, oncology, as well as infection and immunity.

Looking back, I have come to realize that finding molecular mechanisms is not only an academic pursuit it is central to transforming how we approach disease biology. The path of research is often demanding and uncertain, yet each question explored, and each experiment conducted adds a meaningful step to our interpretation. As we look ahead, the ability to decode and precisely target such dynamic signalling systems will be key to developing the next generation of therapeutic strategies in cancer, infection, and immunity.

“PARP14-driven ADP-ribosylation dynamics shape the future of precision therapeutics and next-generation targeted therapies.”

Dr. Kar’s contributions to this field are reflected in his publication in *Genes Dev.*
DOI: *10.1101/gad.353495.125*

| SCIENCE YET TO BE DISCOVERED |

BEYOND SUGAR: THE NEW ERA OF DIABETES RESEARCH

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| Scientific Profile |
| Organization Link |
| Factors Press |

Areas of Expertise: Nanotechnology | Cancer | Diabetes | Malaria | AI/ML | OMICs

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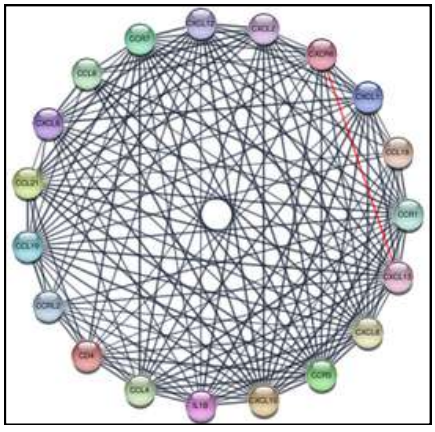
Areas of Expertise: Diabetes | CADD | AI/ML | scRNASeq | BulkRNASeq | Multiomics

When most people hear the term diabetes, they immediately associate it with "high blood sugar." While this is not incorrect, it is only the surface of a much deeper and more complex condition. At its core, diabetes arises from problems related to insulin, a hormone produced by the pancreas that regulates how the body uses glucose for energy. However, the real story extends far beyond insulin deficiency or resistance. Over time, elevated glucose levels trigger a cascade of biochemical changes: Blood vessels become damaged, Kidneys suffer progressive injury, Eyes develop retinal damage, Nerves deteriorate. Pancreatic β-cells are responsible for insulin secretion, but they are surprisingly fragile. Unlike many other cells, β-cells have limited capacity to regenerate. Prolonged stress caused by high glucose, lipids, and inflammation leads to their dysfunction and eventual death or by the time up to 50% of β-cell function may already be lost. Modern medicine offers various treatments, insulin therapy, oral drugs, and lifestyle interventions. However, targeting only blood glucose may not be enough. The goal is shifting from "controlling sugar" to restoring systemic balance.

Balanced diet, regular physical activity, weight management, these approaches improve insulin sensitivity and delay disease progression. Thus, while essential, lifestyle modification alone is rarely sufficient in established Type 2 Diabetes Mellitus (T2DM), current therapeutic strategies for T2DM primarily focus on controlling blood glucose levels through a combination of lifestyle modifications and pharmacological interventions. Among oral drugs, Metformin remains the first-line therapy due to its ability to reduce hepatic glucose production and improve insulin sensitivity; however, it is associated with gastrointestinal side effects, is contraindicated in severe renal impairment, and does not prevent progressive β-cell dysfunction.

OMICS Technologies: Unraveling the Root Causes of Type 2 Diabetes

The transition from symptom-based management to cause-driven therapy in Type 2 Diabetes Mellitus (T2DM) is largely powered by advances in OMICS technologies, which provide a comprehensive understanding of disease biology at multiple molecular levels. Genomics focuses on the study of genetic variations that predispose individuals to diabetes, revealing that certain genes influence insulin secretion, β-cell survival, and metabolic regulation. Transcriptomics examines gene expression patterns, offering insight-

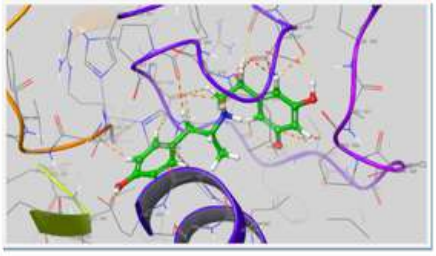


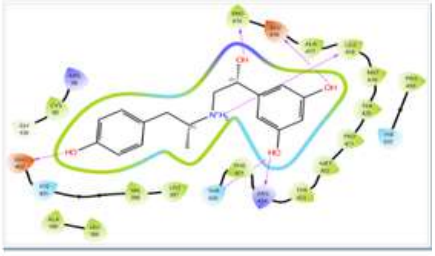
BEYOND SUGAR: THE NEW ERA OF DIABETES RESEARCH

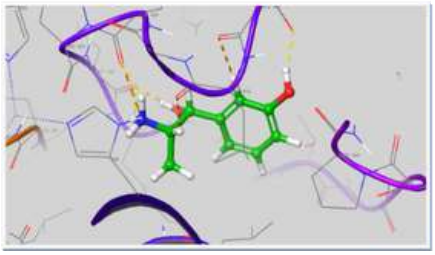
s into which genes are actively involved during disease progression; recent findings highlight that pancreatic β-cells may lose their functional identity under stress, rather than simply undergoing cell death. Proteomics explores the protein landscapes of cells and tissues, uncovering functional disruptions such as increased inflammatory mediators and altered signaling proteins, which directly contribute to insulin resistance and cellular dysfunction. Metabolomics analyzes small-molecule metabolites, providing a real-time snapshot of metabolic changes; specific metabolites like altered lipids and amino acids have been identified as early indicators of diabetes, often detectable years before clinical symptoms arise. Beyond these individual layers, the integration of all these datasets through multi-omics approaches enables a systems-level understanding of T2DM, allowing researchers to map complex biological networks, identify key regulatory hubs, and discover novel therapeutic targets. Collectively, these methodologies are reshaping diabetes research by shifting the focus from managing elevated glucose levels to understanding and targeting the fundamental molecular mechanisms driving the disease.

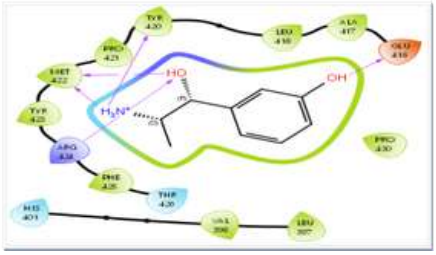
OMICS and Precision Medicine: Toward Personalized Diabetes Care

The integration of OMICS technologies into diabetes research is laying the foundation for precision medicine, where treatment is tailored to an individual's unique molecular profile rather than following a generalized approach. By combining insights from genomics, transcriptomics, proteomics, and metabolomics, researchers can now classify patients into distinct biological subtypes based on their underlying disease mechanisms such as predominant insulin resistance, β-cell dysfunction, or inflammation-driven pathology. This stratification enables clinicians to select therapies that are more likely to be effective for a specific patient, improving outcomes while minimizing adverse effects. Additionally, OMICS-driven approaches are facilitating the identification of novel, highly specific drug targets, allowing for the development of therapies that act precisely at the site of dysfunction, such as pancreatic islets or inflammatory pathways. Another key advancement is the potential for early diagnosis and intervention, as molecular alterations can be detected long before clinical symptoms appear, enabling preventive strategies tailored to individual risk profiles. Ultimately, OMICS is transforming diabetes care from a reactive, one-size-fits-all model into a proactive, personalized, and mechanism-based approach, bringing us closer to more effective and potentially disease-modifying treatments.





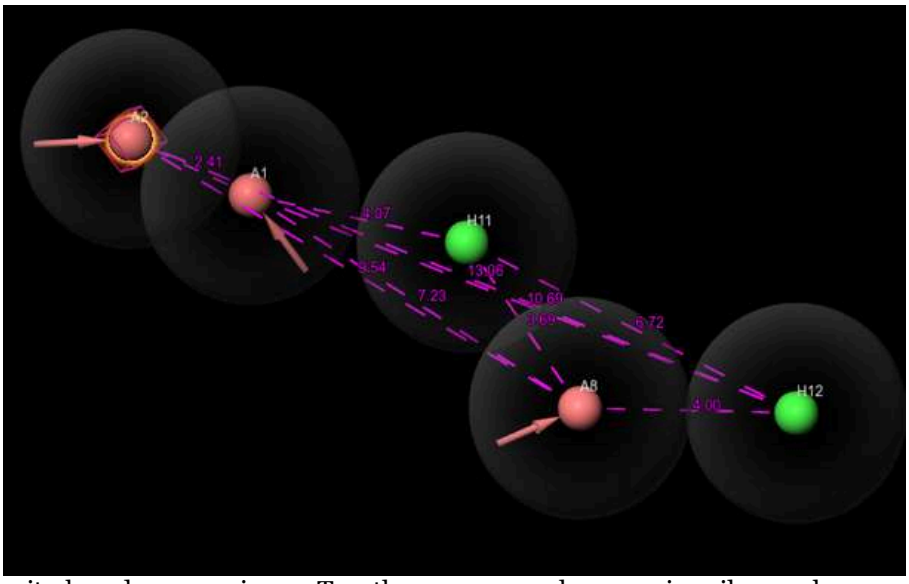




From OMICS to Drug Discovery: Precision Targeting through SBDD and LBDD

Once OMICS analyses identify key hub genes, proteins, or pathways driving Type 2 Diabetes Mellitus (T2DM), the next critical step is translating these findings into targeted therapeutic strategies through advanced drug design approaches. Two major methodologies dominate this phase: Structure-Based Drug Design and Ligand-Based Drug Design. SBDD relies on the three-dimensional structure of target proteins, enabling techniques such as molecular docking, molecular dynamics simulations, and structure optimization to predict how a drug molecule can precisely bind and modulate a specific target, thereby increasing accuracy and reducing off-target effects. In contrast, LBDD is applied when structural information is limited and focuses on known active compounds to design new molecules using approaches like QSAR modeling, pharmacophore mapping, and simil-

BEYOND SUGAR: THE NEW ERA OF DIABETES RESEARCH



arity-based screening. Together, these strategies enhance the efficiency of drug discovery by narrowing down potential candidates to those most likely to interact effectively with disease-specific targets identified through OMICS. This integration creates a highly refined pipeline moving from large-scale molecular data to precise therapeutic design ultimately improving the success rate, specificity, and translational potential of novel anti-diabetic drugs.

Why Modern OMICS-Driven Approaches Outperform Traditional Strategies

The integration of OMICS technologies with advanced drug design approaches such as Structure-Based Drug Design (SBDD) and Ligand-Based Drug Design (LBDD) offers a significant advantage over traditional trial-and-error methods of diabetes treatment and drug discovery. Conventional approaches primarily rely on generalized clinical observations and population-level responses, often focusing on symptom management, particularly glucose reduction without addressing the underlying molecular heterogeneity of Type 2 Diabetes Mellitus (T2DM). When combined with computational drug design techniques like molecular docking and QSAR modeling, significantly improves the accuracy, efficiency, and success rate of therapeutic development. Moreover, these approaches reduce time, cost, and failure rates in drug discovery by prioritizing highly probable candidates before experimental validation. Importantly, they support the development of personalized therapies, ensuring that treatments are tailored to individual patient profiles rather than relying on a one-size-fits-all model. Overall, this modern, integrated framework shifts the paradigm from reactive and generalized care to predictive, precise, and mechanism-based intervention, making it far more effective than traditional strategies.

Diabetes Research at IDDRL: Integrating OMICS and Computational Drug Design

At the IDDRL laboratory, current research efforts are focused on bridging large-scale molecular insights with precision drug discovery to address the complexities of Type 2 Diabetes Mellitus. The lab actively employs advanced OMICS approaches, including bulk RNA sequencing and single-cell RNA sequencing, to uncover differential gene expression patterns, identify disease-associated pathways, and pinpoint key regulatory hub genes involved in β-cell dysfunction, insulin resistance, and inflammatory signaling. These data-driven insights are further translated into therapeutic exploration using both Structure-Based Drug Design and Ligand-Based Drug Design methodologies. Computational platforms such as Schrödinger Suite, SYBYL-X, and GNINA are utilized for molecular docking, virtual screening, and predictive modeling to identify and optimize potential drug candidates. In parallel, the laboratory is also engaged in the discovery of novel therapeutic targets, with a particular focus on the GPR119 receptor, which plays a significant role in glucose homeostasis and insulin secretion. This integrated workflow from OMICS-driven target identification to computational drug design positions the lab at the forefront of precision-based diabetes research, aiming to develop more effective and mechanism-specific therapeutic strategies.

Prof. Kashaw's and Mr. Nema's contributions to this field are reflected in his publication in *Talanta* (2026) DOI: 10.1016/j.talanta.2025.129045.

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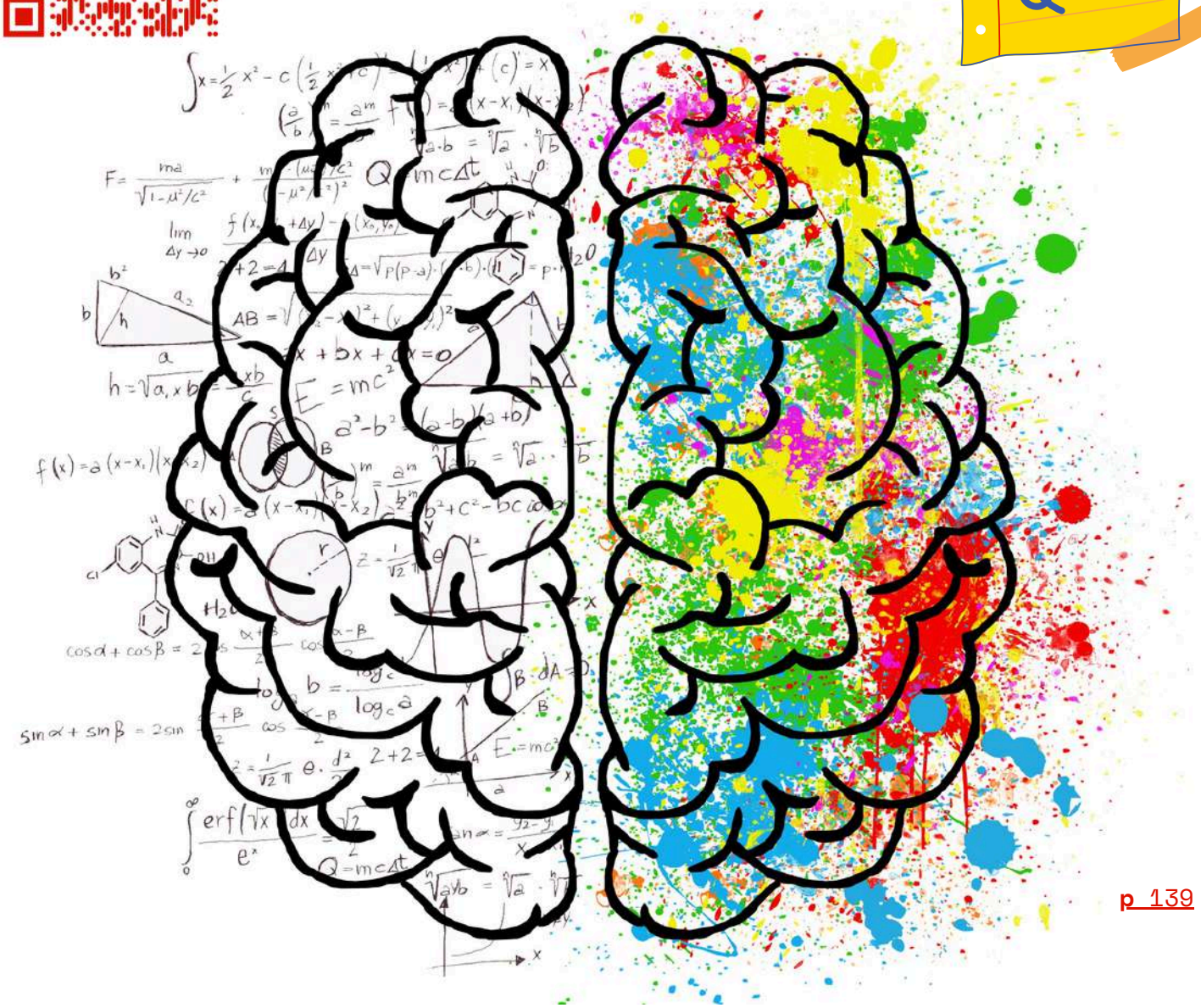
RESEARCHERS LIFELINE RESEARCH HEALTH



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back to school

CURIOUS KID'S

NAME: **Swastik Nanda**

Grade: **4**

SCHOOL: **Vibgyor high, Airoli, Mumbai, India**

FOCUS:

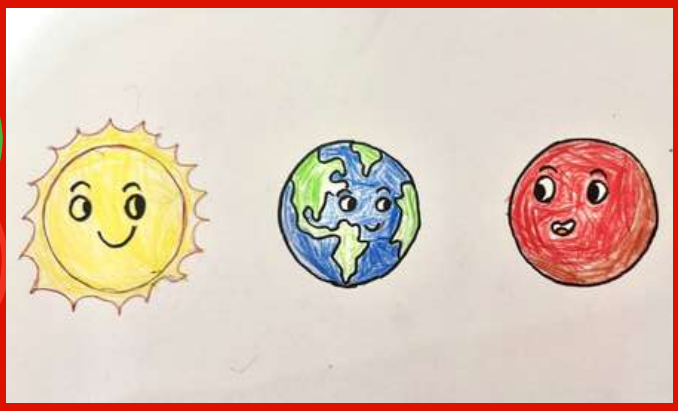
Why is Blood Different Colors in Animals?

In my drawing, I made a boy, an octopus, a frog, a worm, and a bug. But I started wondering do they all have the same blood? Guess what they don't! Humans have red blood because of iron. But deep in the sea, octopus have blue blood with copper. Some worms even have purple blood! And tiny bugs have yellow or clear blood because they breathe in a different way. Why did nature choose so many colors? Maybe each color is a special trick to help them live in their own world. Isn't it amazing that something as simple as blood can be so different and magical?

Give your child a chance to shine! Submit their artwork for an opportunity to be featured in Scientific Kids. Send an image along with a brief explanation or inquiry to hello@rfcsr.org

back to school

CURIOUS KID'S



NAME: **Tanush Prusty**

Grade: Kindergarten

SCHOOL: **Kindergarten Rakefet, Rehovot, Israel**

FOCUS:

Why Do the Sun, Earth, and Mars Look Different?

The yellow one is the Sun. It looks bright and yellow because it is very, very hot and gives off light and heat. The blue and green one is the Earth, our home. It looks blue because of oceans and green for land and plants. The red one is Mars. It looks red because its soil has a lot of iron, like rust, which makes it reddish. They all have cute faces to look friendly! The Sun helps Earth stay warm and full of life, while Mars is colder and dusty. That's why they look different each one is made of different things and has its own special color.

Give your child a chance to shine! Submit their artwork for an opportunity to be featured in Scientific Kids. Send an image along with a brief explanation or inquiry to hello@rfcsr.org

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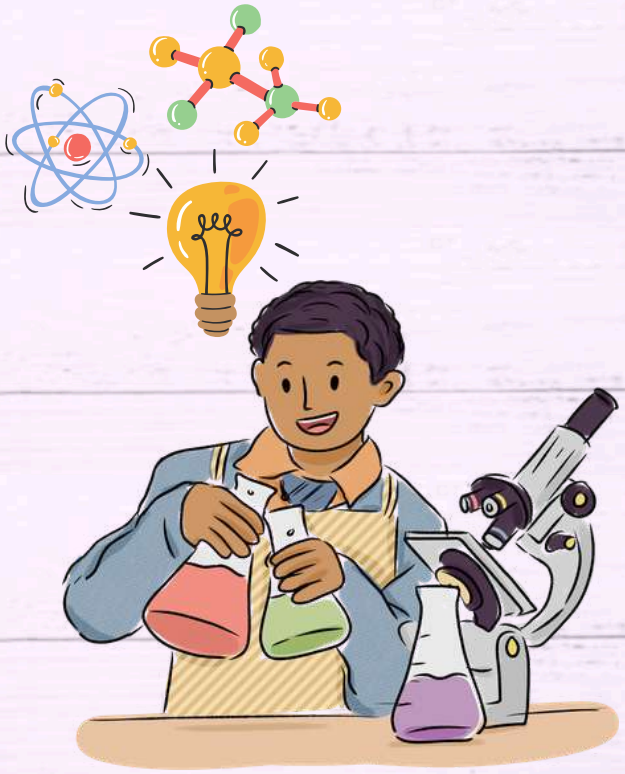

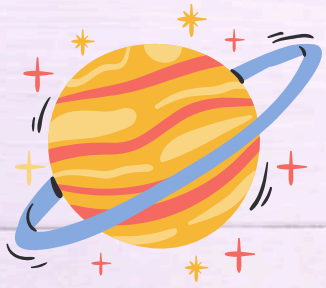

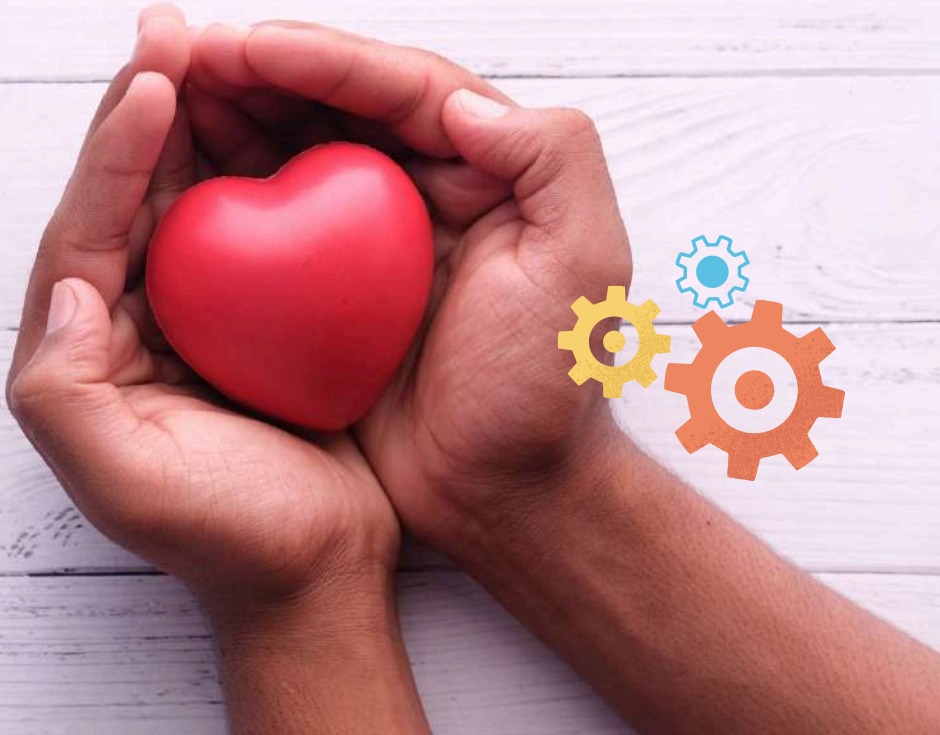

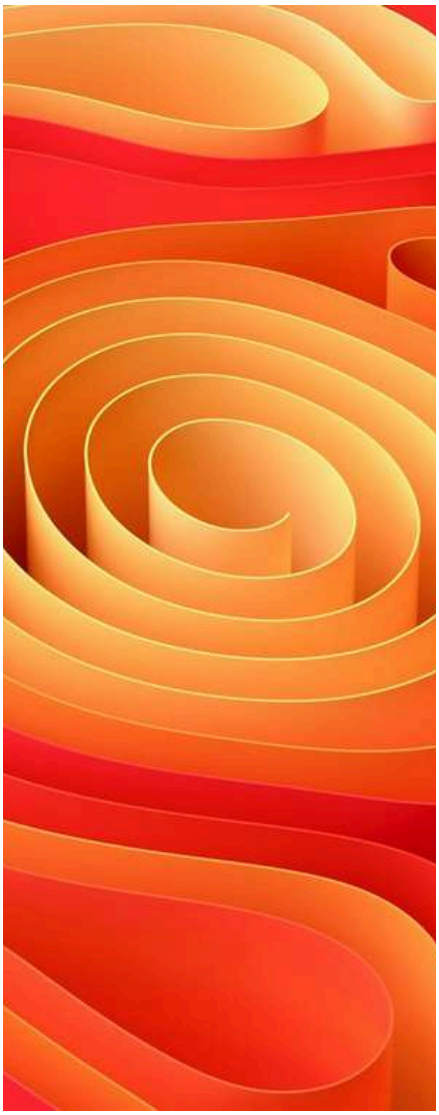

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