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Prof Subhabrata Sen, first Indian to bag prestigious Perkin Prize



Kolkata-born scientist, Prof Subhabrata Sen, has made history by becoming the first Indian to be awarded the prestigious Perkin Prize by the Royal Society of Chemistry (RSC). The prize, established in honour of Sir William Henry Perkin, the inventor of the first synthetic dye, is one of the highest accolades in the field of modern chemistry.

On 25 June, the RSC on its website announced the Perkin Prize, which was instituted in 2020.

Sen, 53, did his undergraduate studies at Narendrapur Ramakrishna Mission Residential College and his post-graduation at Kalyani University.

After completing his post-graduation, Sen proceeded to get a PhD from the University of Missouri-Columbia before obtaining a postdoctoral degree from Colorado State University in the US. Sen is presently a professor of chemistry at Shiv Nadar University. His professional experience includes stints at Pfizer Pharmaceuticals and GVK Biosciences.

Sen and his team of eight have developed a breakthrough technique called Alternate Electrode Electrolysis (AEE). This revolutionary method, for which Sen was the principal investigator, allows chemists to drive reactions with much higher precision and vastly greater sustainability. The challenge was significant—crafting a microcontroller that could precisely direct electrical currents to four electrodes in a tiny electrochemical cell. The hardest part was setting up the cell design and the custom electronics for small-scale reactions.

The Perkin Prize is a tribute to years of hard work undertaken by Sen and his collaborators, with their research published in journals like the RSC's *Chemical Science* (2023), *Cell Press* (2024), and the *Journal of the American Chemical Society* (2024).

Sen told media that the award was a testament to the growing influence of Indian science on the global landscape of innovation.

National Doctor's Day: A Tribute to Dr BC Roy



National Doctor's Day is celebrated every year on 1 July to commemorate the birth anniversary of, and to pay tribute to the legendary physician and Bharat Ratna Dr Bidhan Chandra Roy–the second chief minister of West Bengal.

Dr Roy who was born on 1 July 1882, and served as the CM from 1950 until his death in 1962. He believed that Swaraj would remain a dream unless the people were healthy and strong in mind and body.

His invaluable contributions include establishment of Jadavpur TB Hospital, Chittaranjan Seva Sadan, Kamala Nehru Memorial Hospital, Victoria Institution (College) and Chittaranjan Cancer Hospital.

The BC Roy National Award was instituted in 1962 in his memory and has been awarded annually since 1976.

National Doctor's Day is observed to show the value of doctors in public life and to thank them for their significant roles and responsibilities.

WRITE FOR SCIENCE INDIA

Do you love science? And do you also love writing about it? If your answer to both the questions is 'yes', *Science India* would like to invite you to write for the magazine.

There are a few points we would like you to take care of before embarking on this journey.

Whether you are an established writer or not, please don't send us unsolicited articles as we get tonnes of mail and it becomes difficult to respond to all. If you have a particular topic in mind on which you would like to write, send us a brief with the subject line: Brief for a Proposed Story.

The brief should describe what you want to write on, in about 100-150 words. It is your proposed story in a capsule, in a manner that should get us excited. We will respond only if your proposal is approved, and then share detailed guidelines.

At the same time, we would also like to remind our prospective writers that the bottom line of *Science India* is Indian science, Indian scientists and Indianness.

We are a general readership magazine on S&T and we don't publish scientific research papers. Do look up the previous issues of the magazine on our website to get an idea of the kind of stories we carry. It will help you plan your proposal better.

Best of luck. Mail us at editor@scienceindia.in

Send your letters to editor@scienceindia.in

DISCLAIMER : The views, thoughts, opinions and content expressed in the articles in this magazine are solely that of the authors; and not necessarily of *Science India* or Vijnana Bharati.

Let's Connect

Dear Readers,
As we reach out to you again, Team *Science India* hopes you have been enjoying the monsoon season for all its unique qualities that we miss during peak summer. We have now bidden goodbye to scorching heat of the Indian subcontinent and have found solace in the rains and the widespread lush greenery that they engender. At the same time, we have seamlessly transitioned to a new calibration of life, which we have perhaps, not even noticed. Typical summer foods with hydrating qualities have quietly been replaced in our kitchens by warm, cooked foods that are easy to digest and support immunity.

This dietary transition is scientific knowledge that every Indian family possesses, passed down from generations. This wisdom was perfected by Ayurveda practitioners in ancient times and since then, has become part of the Indian DNA. It is known as Ritu Aahaar (Ritu = season, and Aahaar = nutrition), which is a set of scientific rules that guide dietary habits across the country as per the changing season. This edition of *Science India* brings spotlight on Ritu Aahaar, to reiterate the appropriateness of Indian diet for Indian bodies, as against the onslaught of unhealthy food habits imported from the West along with capitalism.

Dietary transition as per seasons is ancient scientific wisdom that every Indian family possesses, passed down from generations

In other news, we have two scientific achievements of the country to celebrate—the successful completion of the Chenab Bridge in Jammu & Kashmir, and the flight of Group Captain Shubhanshu Shukla to International Space Station (ISS), making him the second Indian to travel to space.

As this edition's special story on Chenab Bridge reveals, it was an engineering feat like no other. The Himalayas are not just the tallest mountain chain in the world but also one of the most volatile, susceptible to tectonic activity that can make the construction of bridges there a risky affair. Yet, Indian engineers, with complex collaboration across disciplines, achieved the unthinkable in creating the world's highest railway arch bridge that now successfully connects Kashmir Valley with the rest of the country.

Group Captain Shukla's journey to the ISS is an equally proud moment for the country. As part of the private Axiom 4 mission comprising astronauts from other countries as well, his flight is an epitome of India's high standing in the global space sector. India has earned this position on the strength of its robust, home-grown space development programme that not only swells our chests with pride but has also become a cynosure of eyes for the rest of the world.

Ralph Waldo Emerson, the American poet, wrote a wonderful poem titled *A Nation's Strength*, in the second half of the 19th century, some of whose lines go as: *Not gold but only men can make/ A people great and strong;/… Brave men who work while others sleep, / Who dare while others fly…/ They build a nation's pillars deep/ And lift them to the sky*. India's scientific achievements today, too, rest on the shoulders of such brave men who toiled hard to lift the country to the sky. In this edition, we salute two such scientific gems—Prof Yash Pal and Dr Saroj Ghose. Prof Yash Pal, whose death anniversary falls on 24 July, was a well-known figure who took science to the masses and is remembered as an institution builder, among other things.

Dr Ghose, on the other hand, will always be remembered as the 'Father of Indian Science Museums'. Driven by the zeal to popularise science, his contributions were celebrated internationally. We pay tribute to this legendary science communicator, who passed away on 17 May 2025.

This edition carries all this and more for a wholesome read through the month. The team hopes that the readers will enjoy reading it as much as we enjoyed putting it together.



Group Captain Shubhanshu Shukla (second from left) with crew members of Axiom Mission 4

Axiom Mission: Second Indian in Space Ignites Dreams

The Ax-4 mission, carrying Group Captain Shubhanshu Shukla as a crew member, is a milestone for India, and a giant leap for commercial human spaceflight ambitions

In a proud moment for India and the global space community, a brand-new SpaceX Dragon spacecraft roared into the skies on 25 June 2025. This mission, named Axiom Mission 4 (Ax-4), carried a multinational crew to the International Space Station (ISS) after overcoming multiple technical delays. Among the four astronauts aboard was Indian Air Force Group Captain Shubhanshu Shukla, marking the first Indian presence on an Axiom mission and only the second time an Indian has travelled to space.

Founded nine years ago by former NASA ISS programme manager Michael T Suffredini and entrepreneur Kam Ghaffarian, Axiom Space is pursuing an ambitious vision: to build the world's first private space station, replacing the ISS (International Space Station) by the end of this decade. The Ax-4 mission represents a significant step in realising that dream, proving that commercial human spaceflight is not only feasible but also scientifically valuable. This is SpaceX's 18th crewed mission since it began human launches in 2020, underscoring how rapidly the landscape of space exploration has evolved from government-only programmes to private enterprise.





■ **Dr Biju Dharmapalan & Dr Navneet Kumar Gupta**

A FLAWLESS LIFTOFF

The mission lifted off from NASA's iconic Launch Complex-39A at the Kennedy Space Centre in Florida at 12:01 p.m. IST (2:31 a.m. EDT) on 25 June. The launch vehicle, SpaceX's trusted Falcon 9 rocket, successfully propelled

All Images Courtesy: NASA

the Dragon capsule into low Earth orbit in a flawless night-time liftoff. After about a day of orbital manoeuvres, Axiom Space's Axiom Mission 4 (Ax-4) crew successfully reached the International Space Station in a journey that lasted approximately 28 hours. The SpaceX Dragon spacecraft docked with the International Space Station Harmony module at 6:21 a.m. ET (4:01 pm IST) on 26 June, while soaring over the expansive North Atlantic. After seamlessly docking to the orbiting laboratory, Ax-4 Commander Peggy Whitson, Pilot Shubhanshu Shukla, Mission Specialist Sławosz Uznanski-Wisniewski, and Mission Specialist Tibor Kapu entered the space station around 8:14 a.m. EDT.

The crew was welcomed aboard by its seven current resident occupants—three astronauts from the US, one from Japan and three cosmonauts from Russia. Commander Whitson presented her crewmates with their official astronaut pins and orbital flight numbers, declaring Shukla to be the 634th, Uznanski-Wisniewski the 635th, and Kapu to be the 636th astronaut to orbit Earth.





The crew of Axiom-4 (in black), including Shubhanshu Shukla, arrived at the International Space Station, ferried by SpaceX on a private flight

CHRISTENING THE SPACECRAFT

Following spacefaring tradition, the Ax-4 crew christened their spacecraft once they reached the orbit. They chose the name 'Grace', symbolising the poise and purpose behind their mission.

"We had an incredible ride uphill, and we now set our course for the International Space Station aboard the newest member of the Dragon fleet—our spacecraft, Grace," Commander Whitson declared. Grace, she explained, was more than just a name. "It reflects the elegance with which we move through space against the backdrop of Earth. It speaks to the refinement of our mission, the harmony of science and spirit, and the unmerited favour we carry with humility," she said. Such naming rituals are a powerful reminder that such spaceflights are also an act of goodwill and cooperation among nations.

A MULTINATIONAL CREW OF FIRSTS

This flight marks the maiden journey to space for three astronauts: Group Captain Shubhanshu Shukla from India, Sławosz Uznanski-Wisniewski from Poland, and Tibor Kapu from Hungary. Each is the first from their nation to participate in a mission to the ISS.

Leading the team is Dr Peggy Whitson, a veteran American astronaut who, with this mission, surpasses 700 cumulative days in space — the most by any American.

Adding a touch of tradition and whimsy, the crew also brought along a small plush swan named Joy, which serves a special purpose: as a zero-gravity indicator. When Joy began to drift, it signalled to the astronauts that they had escaped the Earth's pull.

"Joy represents the shared aspirations of three nations united in their return to human space flight," Whitson explained. The swan, she noted, is rich in symbolism—wisdom in India, resilience in Poland, and grace in Hungary.

The Ax-4 crew will spend approximately two weeks aboard the space station, conducting over 60 scientific experiments and STEM outreach programmes, the highest number for any Axiom mission so far. Their work includes critical research in biomedical science, material engineering, and space technologies—all with potential benefits for life back on Earth.

INDIA'S ROLE: FROM SYMBOLISM TO STRATEGY

For India, the inclusion of one of its citizens on a private international spaceflight mission is both symbolic and strategic. It signals India's growing stature in global space exploration efforts and complements its own ambitions through

KNOW THE CREW MEMBERS OF AXIOM MISSION 4

PEGGY WHITSON – Commander (United States, Axiom Space)
Dr Peggy Whitson, one of the most iconic figures in human spaceflight, serves as the mission commander. A biochemist by training, she holds degrees in biology and chemistry from Iowa Wesleyan College and earned her PhD in biochemistry from Rice University. Inspired by the 1969 moon landing, Whitson grew up on a farm near Beaconsfield, Iowa, and dedicated her life to space science. She has accumulated 675 days in space across four missions, making her the most experienced American astronaut and the world's most experienced female astronaut. During her NASA tenure, she conducted extensive research across biology, biotechnology, and Earth sciences. Today, she is the Director of Human Spaceflight at Axiom Space, guiding the company's commercial spaceflight ambitions. Her accolades include the NASA Leadership Medal, TIME 100 (2018), and the Women in Aviation Lifetime Achievement Award (2017).

SHUBHANSHU SHUKLA – Mission Pilot (India, ISRO)
Group Captain Shubhanshu Shukla (born 10 October 1985, Lucknow) is a decorated Indian Air Force fighter-combat leader, accomplished test pilot, and ISRO astronaut. The youngest of three siblings, he was born to Shambhu Dayal Shukla, a retired government officer, and Asha Shukla, a homemaker.

He grew up in Lucknow and completed his schooling at City Montessori School. Inspired by the 1999 Kargil War, he set his sights on a military career, successfully clearing the NDA examination. In 2005, he completed his military training and earned a Bachelor of Science degree in Computer Science from the National Defence Academy.

Selected for the flying branch, he underwent rigorous training at the Indian Air Force Academy and was commissioned into the Fighter stream of the Indian Air Force as a Flying Officer in June 2006. Over his distinguished career as a combat leader and test pilot, he has amassed more than 2,000 flying hours on a range of aircraft, including the Su-30 MKI, MiG-21, MiG-29, Jaguar, Hawk, Dornier, and An-32.

In 2019, the Institute of Aerospace Medicine (IAM), under the Indian Air Force, shortlisted Shukla for the astronaut selection process for the Indian Human Spaceflight Programme. The following year, he travelled to Russia to begin basic astronaut training at the Yuri Gagarin Cosmonaut Training Centre, completing it in 2021. Upon returning to India, he continued advanced training at the Astronaut Training Facility in Bangalore while simultaneously earning a Master of Engineering degree in Aerospace Engineering from the



Indian Institute of Science.

Commissioned into the IAF fighter wing in 2006, he rose steadily through the ranks, attaining the rank of Group Captain in March 2024—a testament to his dedication and service. On 27 February 2024, Indian Prime Minister Narendra Modi formally introduced Shukla as one of the chosen astronauts undergoing intensive preparation for Gaganyaan, India's first human spaceflight mission.

SLAWOSZ UZNANSKI-WISNIEWSKI – Mission Specialist (Poland, ESA)
Slawosz Uznanski-Wisniewski, an engineer and scientist from Poland, adds cutting-edge technical expertise to the Ax-4 team. He holds dual MSc degrees from Łódź University of Technology and Université de Nantes, along with an engineering diploma from Polytech'Nantes. In 2011, he earned a PhD from the University of Aix-Marseille, focusing on radiation-hardened electronics for space. At CERN, he played a vital role as a reliability expert and project leader. From 2018 to 2020, he served as Engineer in Charge of the Large Hadron Collider, ensuring the 24/7 operation of one of the world's most advanced scientific instruments. His experience makes him a valuable asset as a mission specialist aboard Ax-4.

TIBOR KAPU – Mission Specialist (Hungary, HUNOR)
Tibor Kapu, a mechanical engineer from Hungary, rounds out the crew. Born in 1991 in Nyíregyháza, he studied mechanical engineering at Budapest University of Technology and Economics, specialising in polymer technology. His professional journey includes work in pharmaceuticals, logistics, hybrid automotive batteries, and aerospace technology. From 2022, he focused on space radiation protection and joined the Hungarian Astronaut Program. Kapu underwent extensive training in space engineering, flight simulation, physical endurance, and scientific research methods. As an Ax-4 mission specialist, he brings Hungary's technological excellence to the global stage.

the Gaganyaan human spaceflight programme. For India, despite its impressive achievements with lunar and Mars missions, this represents a crucial milestone in human spaceflight capability.

India is set to embark on a new chapter in its spacefaring journey with the successful Axiom Mission 4 (Ax-4), a moment as significant as Rakesh Sharma's 1984 mission onboard the erstwhile Soviet Union's Soyuz spacecraft.

Not only was the ISS the destination of this flight, but the pilot who conducted the expedition was Group Captain Shubhanshu Shukla of the Indian Air Force, rendering it historic. After 41 years, an Indian was able to witness and observe the Earth from space, this time as a co-pilot on a private, multinational mission that officially marked India's entrance into the commercial spaceflight era. As India's first astronaut to board the ISS and only the second ever Indian in space, Shukla not just piloted a spacecraft—he carried the collective dreams of 1.4 billion people. His statement, "I carry hopes and dreams of a billion hearts," resonates deeply in a country where science and aspiration are now more intertwined than ever.

The mission represents India's emergence as a collaborative partner in global space science, in addition to its national pride. NASA, ESA, ISRO, and SpaceX collaborated to execute the Ax-4 voyage, which is managed by Houston-based Axiom Space. ISRO has not only acquired a seat in space but also a stake in long-term strategic positioning, training, and knowledge, with a $59 million investment.

The timing of the mission is crucial. Shukla's Ax-4 experience serves as an indispensable trial run for the Gaganyaan mission, which is scheduled to launch in 2027 and will be India's inaugural human spaceflight. The Ax-4 research complement includes around 60 scientific studies and activities representing 31 countries, including the US, India, Poland, Hungary, Saudi Arabia, Brazil, Nigeria, UAE, and nations across Europe. ISRO has shortlisted seven microgravity research experiments proposed by Indian PIs (Principal Investigators)



Image Courtesy: Internet

"We will be going farther and farther from planet Earth…We really need to preserve what we have, which means we need to end conflicts, we need to forget about our weapons…this planet belongs to everyone. It is not a sole preserve. I am hoping that India will be a modern leader in the years to come, and will succeed in its (space) mission"

— Rakesh Sharma, former Indian Air Force officer who became the first Indian to travel to space on 3 April 1984

from various national R&D laboratories and academic institutions, which Group Captain Shukla would be conducting during his 14-day stay at the ISS.

These studies include groundbreaking research on the biology of tardigrades in space, the cultivation of crops and phytoplankton in microgravity, and the investigation of human cognition in a zero-gravity environment. This research has far-reaching implications that extend beyond national borders and into the future of human existence in space. The microgravity conditions aboard the International Space Station offer unique opportunities to conduct experiments that are not possible on Earth. The potential discoveries from this mission could benefit millions of people on Earth, ranging from pharmaceutical research that could lead to new medicines, to materials science investigations that could revolutionise manufacturing, and biological studies that could unlock secrets of human adaptation in space. Moreover, using the Amateur Radio on the ISS (ARISS), the astronauts will hold live classes and interactive sessions with students, experts and VIPs from ISS, as part of their 14-day mission.

India's objective of establishing a space station (Bharatiya Antariksh Station) by 2035 and a lunar mission by 2040 is no longer perceived as unrealistic. Although Group Captain Shukla may be in orbit above the Earth, his mission is deeply rooted in India's future space missions. In addition to fulfilling his responsibilities at the International Space Station, he inspires a nation to become a pioneer in the cosmos rather than merely a participant. In his first message from the mission, Shukla said, "This is not the start of my journey to the ISS but the start of India's human space programme. I want my countrymen to become part of this journey, let us join together and start India's human space programme. Jai Hind Jai Bharat". It's no exaggeration to call Ax-4 a milestone comparable to India's earliest space milestones. While Rakesh Sharma's flight was a testament to Cold War alliances, Shukla's mission embodies a new era—one defined by international cooperation and private enterprise. In many ways, the mission bridges past and future, honouring the legacy of pioneers while laying the groundwork for a new generation of Indian astronauts.

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EXCLUSIVE

CHENAB BRIDGE
INDIA'S CROWN JEWEL OF ENGINEERING

The highest railway bridge in the world is not just a symbol of national pride but a testament of growing confidence of Atmanirbhar Bharat

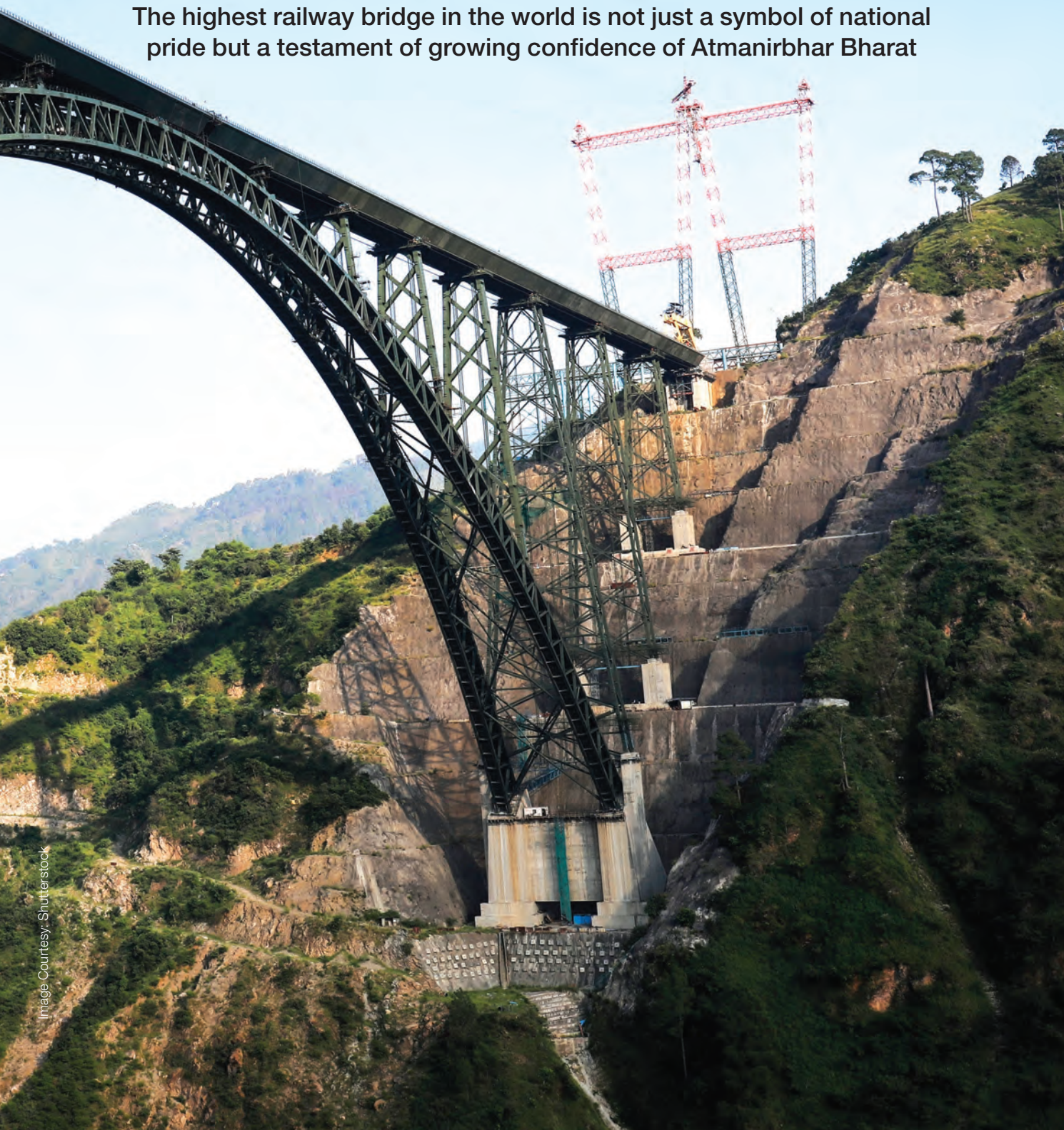


Image Courtesy: Shutterstock

The date of 6 June 2025 will forever be etched in the annals of Indian engineering history. The inauguration of the Chenab Railway Bridge by Prime Minister Narendra Modi was not merely the culmination of a mammoth infrastructure effort—it marked the realisation of an audacious dream once considered impossible. Towering 359 meters above the Chenab River, higher than even the Eiffel Tower, this engineering marvel stands as a tribute to human spirit, scientific precision, and national resolve. The Chenab Bridge stands as a shining example of Atmanirbhar Bharat in action—where Indian expertise, leadership, and innovation took center stage in designing, executing, and overcoming extraordinary engineering challenges. From indigenous geotechnical solutions to advanced construction techniques, the project reflects India's growing self-reliance and confidence in delivering world-class infrastructure.



■ **Prof T G Sitharam**

But as I stood beneath the steel arch, watching this colossal structure gleam in the sun, I wasn't just admiring its physical form—I was overwhelmed by the enormous reservoir of talent, perseverance, and technical ingenuity that shaped it. This bridge is not just about spans and segments—it is about every calculation rechecked at midnight, every gust of wind battled on site, every rock face negotiated with care, and every soul who gave their all to see it stand.



Image Courtesy: Prof T G Sitharam

I visited the site as early as January 2005 and stayed with the project as a team leader for slope stabilisation and foundation design till the steel bridge erection started by AFCONS. I would like to express my thanks to AFCONS leadership for having faith in my capability of geotechnical design. I also thank my team and all my students at IISc, Bengaluru, who contributed to this project. I wish to extend my heartfelt gratitude to every individual who contributed to the making of the Chenab Bridge. Their unwavering dedication, deep knowledge, and exceptional engineering skills have gifted India a structure that is not only the highest railway bridge in the world but also a symbol of national pride. This bridge is a shining example of what teamwork, vision, and perseverance can achieve. It is certain to draw the attention of people from across the globe—not just for its scale and design, but also for the extraordinary story behind its creation.

MONUMENTAL CONSTRUCTION BY A DILIGENT TEAM

The choice of location—Jammu and Kashmir—adds even greater significance to this engineering marvel. Strategically and historically, building such a bridge in this region is monumental. We often speak of crowning achievements, and in many ways, the Chenab Bridge is exactly that: a magnificent crown placed on the head of our nation. Nestled amidst the majestic mountains of Jammu and Kashmir, this bridge does not merely connect two banks of a river—it connects hearts, aspirations, and the promise of a united, forward-looking India.

First and foremost, the unwavering resilience and leadership of Subramaniam Krishnamurthy, Executive Vice Chairman of Afcons Infrastructure Ltd, deserve high praise, along with the dedicated efforts of the senior administrators at Afcons. Equal credit must go to the Indian Railways, particularly the Northern Railway and the Konkan Railway



Image Courtesy: Prof T G Sitharam

Prof Sitharam, Chairman of AICTE, conducts a MASW (Multichannel Analysis of Surface Waves) survey at Chenab Bridge project on 24 December 2015

Corporation Limited, whose engineers played a pivotal role in planning this monumental project—subsequently brought to life by Afcons Infrastructure.

I extend my heartfelt salute to the structural visionaries behind the conceptualisation and execution of this engineering marvel: Esko Jarvenappa, Pekka Pulkkinen, Erik Erickson, and Matti Jarvenappa from WSP Finland; Hopf and Killian from LAP Germany; the late Sunil Mungi from Afcons; and the brilliant minds of Dhananjaya Bhide and Shashank Rajbhoj, along with their dedicated teams.

Their decision to adopt a parabolic arch design was far more than a structural or aesthetic choice—it was a scientifically grounded solution, deeply rooted in centuries of mathematical and engineering wisdom. The parabolic arch is an extraordinary form—a naturally self-supporting structure. Imagine suspending a flexible chain between two high points. The shape it assumes under its own weight is a catenary curve. Now, if we approximate this catenary as a parabola and solidify the shape, we essentially get a reversed version of a hanging chain. When gravity acts downward on such a solidified parabolic form, the internal forces transform entirely into compression. Flipping the entire structure now produces a load-bearing arch, with compressive stresses concentrated precisely along the central axis of the arch. This stress alignment ensures maximum structural efficiency and stability. The Chenab Bridge's massive steel arch—spanning 467 meters—follows this principle, distributing loads seamlessly and resisting both seismic forces and wind loads across the rugged Himalayan terrain. Parabolic arches are not only beautiful but extremely resilient, as they transfer forces downward into the foundations without introducing bending or torsional forces that could destabilise the structure.

This engineering logic translated into action through the dedicated efforts of proof-checkers and review experts like David Meckanzie from Flint & Neil, and Philip Ward from AECOM. Their rigorous vetting and validation of design calculations ensured not just form but functional resilience—enabling the bridge to withstand harsh environmental conditions, dynamic loads, and potential seismic activity.

While the iconic arch is the visual signature of the Chenab Bridge, its true strength lies in the people who breathed life into it. The project was led by Subramaniam, Executive Vice Chairman of Afcons Infrastructure Ltd., and Paramasivan Srinivasan, Managing Director, Afcons, along with Giridhar Rajagopalan, Manivannan, Mandar Karnik, and their dedicated operational teams at Afcons. They were supported by exceptional freelance consultants such as Andrew Faessler, S B Joshi, Sena Kumarasena, and Khanolker—each of whom battled nature and terrain on a daily basis. These experts spearheaded the erection of one of the most complex cable crane systems in the world, spanning 915 meters across the Chenab gorge. This engineering feat enabled the precise placement of the arch ribs and deck segments at daunting heights, with millimetre-level accuracy.

NUTS AND BOLTS

Stabilising the slopes that cradle this engineering marvel required geological mastery. The geotechnical challenges were unprecedented: fractured dolomitic rocks, steep natural slopes ranging from 43° to 77°, and constant threat of rockfall and subsidence. Under my leadership from the Indian Institute of Science, Bengaluru, many of my colleagues and students worked on slope stability of both abutments and foundation design of Chenab bridge. Our man contributions are:

a) For the case of jointed rock mass slopes of Chenab bridge site, the optimum slope and its stability analyses with selection of appropriate rock mass parameters.

b) Flattening of the slopes, an optimum solution wherever the trend of the line of intersection is close to the dip of the slope to avoid the formation of the wedge at the first instance during the preliminary analyses.

c) Proposed an effective and efficient methodology of wedge failure analyses.

d) The importance of carrying out stability analysis of slopes during the construction stage with due consideration for the construction methodology and shear strength parameters corresponding to construction stage has been brought out. The parameters to be adopted in the construction stage were also brought out.

e) Special considerations for wedge failure analyses in zones of high seismicity have been brought out and supported by Sliding Block analogy.

f) Counter-intuitive findings that are validated by Sliding Block Analogy.

g) The approach of "Holistic design of Slope stabilization measures" encompassing Top-down execution will ensure timely, safe, and efficient execution of slope stabilisation measures has been developed and implemented in the field.

h) The concept of "Design as You Go" for the validation of the design parameters and its successful implementation in the field has been presented.

i) Optimum approaches for determining bearing capacity of foundations on jointed rock mass are proposed.

j) The efficacy of consolidation grouting for improving the deformation behaviour of foundations on jointed rock mass is established.

We visited the site and adopted a dynamic "design-as-you-go" approach. This enabled real-time adjustments to geotechnical interventions. We deployed pre-splitting techniques, advanced grouting strategies, Dywidag tie rods, and high-performance shotcrete reinforced with steel mesh. Anchor blocks were anchored deep into the rock to ensure slope stability under both static and dynamic loading conditions. Prof T Rama Murthy alongside Prof K S Rao, Prof K G Sharma also joined the investigations on behalf of the Indian Railways on various occasions.

Another critical dimension was welding and wind engineering. Dr Suresh from the Welding Research Institute, Trichy; A K Mandal, former Director of RDSO (Research Design and Standards Organization); and the experts from Force Technology, Denmark, undertook the herculean task of ensuring seamless welding of thousands of components under challenging conditions. This was paired with aerodynamic studies to counter wind-induced vibrations, particularly vortex shedding and flutter, that could jeopardize structural integrity. Their findings led to vital modifications, making the bridge robust against the high-velocity winds common in this region. The bridge is equipped with advanced structural health monitoring systems along with sensors on its foundations.



Image Courtesy: Prof. T G Sitharam

A photo from the year 2015, when the construction for the iconic Chenab Railway bridge had just begun

The success of the bridge was also due to a core team that worked quietly but effectively under the leadership of K Subramaniam. Pillars of this team—Bhoem, V Prasada Rao, R Ananta Kumar, D K Kunar, V J Pai, VVRV Prasada Rao, K M Rao, Vishwa Murthy, Y Tagore, Srinivas Mantrala, Shankar, Mandar Karnik, Dhanajaya Bhide, and Umesh Kaul—ensured site coordination, logistics, and manpower management at a scale rarely witnessed in civil projects of this magnitude.

A LIVING CLASSROOM

Behind the numbers and nuts and bolts, there were guardians of process and people. K N Pandey's meticulous oversight of quality control, Rama Krishna Rao's unyielding focus on safety protocols, S Paramsivan's deft financial management, and Bhakti's compassionate leadership in human resources ensured that the ecosystem surrounding the bridge was healthy, efficient, and sustainable. Their work may not be visible in steel but is etched into the soul of the project. While I may have inadvertently missed mentioning some names, I extend my deepest respect and heartfelt tribute to each and every individual who played a role—directly or indirectly—in the planning, design, engineering, and construction of this iconic bridge. Your collective efforts have created a landmark that will be remembered for generations.

The Chenab Railway Bridge is more than just a transportation corridor—it is a symbol of national integration, scientific triumph, and engineering vision. It redefines what's possible when a nation dares to dream, and its engineers resolve to deliver.

For students and young engineers across India, this bridge must serve not just as a structural landmark, but as a living classroom. It teaches us that the true strength of engineering lies not in textbooks alone, but in the courage to take on impossible odds and the competence to solve them one calculation at a time.

As Chairman of AICTE (All Indian Council for Technical Education) and someone who was deeply involved in this project for more than 15 years, I say this to all aspiring engineers: Engineering is not just about learning equations—it is about building legacies. The Chenab Bridge is one such legacy. May it inspire generations to come to reach higher, dig deeper, and build stronger.

Let us honour not just the bridge, but the countless bridge builders who made this marvel a reality.

Jai Hind!

**The writer is Chairman, AICTE (All India Council for Technical Education) and was Geotechnical Consultant on the Chenab Bridge Project (2005–2020).*



Image Courtesy: Shutterstock

Not a Comeback, but a Leap Forward

India's present global heft is dependent on IT exports and digital finance, but the next step demands scientific and innovation-led foundation

For decades, the American Dream drew some of India's brightest minds away from home. Scientists, doctors, engineers, economists, and entrepreneurs chose to build their futures abroad, drawn by robust institutions, merit-based systems, and cutting-edge infrastructure. This migration wasn't an act of disloyalty—it was a rational response to limited options in India at the time. The country was still finding its feet, and the West offered a head start.

But times have changed—and not just in India. Across the world, immigration policies are tightening. In the United States, even green card holders now face heightened scrutiny under proposed rules that could require location registration for foreign nationals. In Europe, political shifts have narrowed pathways to long-term inclusion. These changes provoke a deeper question—not about legality, but about identity and belonging. For many Indians abroad, a growing sense of exclusion has turned into a quiet discomfort.



■ Dr Kishore Paknikar

Meanwhile, India has transformed. The country once left behind in search of opportunity is no longer the same. It is younger, more connected, digitally advanced, and globally confident. It is not perfect, but it is promising. And for many global Indians, the moment is ripe for reflection: What am I building, and for whom?

INDIA AT A CROSSROADS—AND A GATEWAY

India's recent leap to become the world's fourth-largest economy, overtaking Japan in nominal GDP, is a landmark achievement. But such milestones, while symbolic, are not endpoints. They are invitations. A strong economy alone does not guarantee better science, stronger institutions, or lasting innovation. For that, a nation needs deep intellectual



capital—and the courage to invest in it.

History is unambiguous. The world's most advanced nations have all built their status on scientific strength. The United States invested in basic and applied research to fuel its innovation economy—from NASA to the NIH, from the internet to mRNA vaccines. Israel turned national survival into scientific supremacy by linking diaspora expertise with public policy. China, through coordinated planning, is now a global force in AI, semiconductors, and quantum technologies.

India has grown largely through its services sector, particularly IT exports and digital finance. But the next leap—from competence to leadership—demands something more: a scientific and innovation-led foundation.

This calls for a fundamental shift in how we think about science—not as an isolated pursuit, but as an enabler of national transformation. The notion of scientific power must now take precedence over mere scientific freedom. India must move from scattered, curiosity-driven research to mission-mode efforts that tackle its most pressing challenges: clean water, sustainable agriculture, affordable healthcare, and climate resilience. The time has come for problem statements to emerge not only from Western labs but also from Indian grassroots realities. When these are paired with the intellectual capital of global Indians, real breakthroughs become possible. It is in this spirit that science must be seen not as expenditure, but as a strategic investment—fuelling Atmanirbhar Bharat with intellectual self-reliance.

India must also invest actively in scientific storytelling—bringing visibility to its milestones, homegrown technologies, and research heroes. Public perception shapes policy priority. When science becomes aspirational to the next generation, it creates a virtuous cycle of curiosity, career choices, and national contributions. A nation's innovation capacity remains incomplete without a culture that celebrates and values knowledge.

CREATING CONDITIONS FOR SCIENTIFIC EASE AND EXCELLENCE

Encouragingly, India has begun reshaping its scientific ecosystem with long-overdue reforms. Procurement norms have been overhauled to ease operations in research institutions. Scientists can now directly purchase equipment and consumables up to Rs 2 lakh without quotations, while procurement thresholds for tenders have been raised significantly. Institutional heads have been empowered to approve global procurements up to Rs 200 crore. Importantly, the earlier compulsion to purchase exclusively via GeM or GTE platforms—often inadequate for high-end scientific equipment—has been lifted.

India's public spending on R&D remains around 0.7% of GDP, far below South Korea (4.9%), Israel (5.4%), and China (2.4%). And we have 260 researchers per million compared to 4,000 in the US

Equally significant is the shift in administrative burden. Tasks like utilisation certificates, expenditure tracking, and reporting—once handled by Principal Investigators—are now moving to trained administrative teams. These steps signal a turning point: science in India is being trusted again. For returnees accustomed to streamlined systems abroad, this marks not just operational convenience but a restoration of professional dignity.

THE SCIENTIFIC BACKBONE OF A DEVELOPED INDIA

Yet, these reforms, while important, are just the start. India's public spending on R&D remains around 0.7% of GDP—far below South Korea (4.9%), Israel (5.4%), and China (2.4%). The country has only around 260 researchers per million people, compared to over 7,000 in Israel and 4,000 in the U.S. These are not merely gaps; they are opportunity costs.

The establishment of the Anusandhan National Research Foundation (ANRF) offers a fresh institutional approach. But to succeed, ANRF must provide long-term, predictable funding, encourage interdisciplinary work, and prioritise societal impact. Research grants should support not only scientific excellence but also reproducibility, policy relevance, and translational value.

Evaluation systems must be reformed. India must move beyond simple metrics like publication counts or citation indices. The critical questions are: Did this research solve a problem? Was it independently validated? Did it create public value?

A NATIONAL RECONNECT AND RETURN MISSION

This is where India's global minds can make a decisive difference. The country must actively facilitate their return—not just physically, but professionally and institutionally. A National Reconnect and Return Mission should be launched to make this happen.

This initiative could offer:

- A single-window system for employment, housing, school admissions, and spousal relocation
- A Diaspora Sabbatical Scheme for mid-career professionals to work in Indian institutions on impact-driven projects
- Fast-track lateral entry into scientific missions, public policy, and R&D institutions
- A National Registry of Global Indian Experts aligned with national priorities—water, energy, health, education, and strategic tech

Such a mission would signal more than intent—it would embody national purpose.

RETHINKING THE SCIENCE–STARTUP PIPELINE

India now boasts the world's third-largest startup ecosystem. But a closer look reveals that most activity is concentrated in low-risk domains: food delivery, entertainment, fintech, and edtech. Deep tech—startups working on semiconductors, quantum computing, synthetic biology, or clean energy—remains underfunded and underserved.

A 2022 NASSCOM–Zinnov study found that fewer than 500 Indian startups qualify as true deep tech ventures. Among them, very few receive follow-on funding. By contrast, developing a medical device, space-grade material, or AI-driven manufacturing platform often requires Rs 10–15 crore just for early prototyping.

India must foster an innovation ecosystem that rewards audacity. To do this, we need:

- A Rs 10,000 crore Diaspora Venture Catalyst Fund for returnee-led, high-impact ventures
- Co-located translational research parks near IITs, IISERs, and CSIR labs
- Public procurement pipelines to absorb innovative products from Indian start-ups
- Policies that de-risk patient capital and reward moonshot thinking

We often say we want the next Tesla or Moderna from India. But we forget that such breakthroughs took a decade or more—and generous public and private support. Returnees from global innovation hubs can help us build this long game.



CREATING CITIES THAT INVITE TALENT

Talent thrives in ecosystems. Cities like Bengaluru, Pune, Hyderabad, and Ahmedabad should be declared Technology Magnet Cities with:

- Efficient public transport and green infrastructure
- International schools and knowledge districts
- Startup-friendly policies and affordable housing
- High-speed digital infrastructure and urban livability

These cities can serve as launchpads for innovation clusters that integrate academia, industry, and government.

For returnees, the question is not just "Can I work here?" but "Can my family live here, thrive here, belong here?" With thoughtful planning, the answer can be 'yes'.

THE EMOTIONAL CALCULUS OF RETURNING

Returning to India is not merely a career move. It is a decision laden with emotion, identity, and aspiration. It involves uprooting routines, adapting to new realities, and reconciling comfort with contribution.

But the emotional balance is shifting. Abroad, many Indian-origin professionals feel respected yet peripheral. Despite long-term residency, full belonging often remains elusive. In contrast, India today offers something more profound: meaningful agency—the opportunity to build institutions, shape discourse, and influence public good.

Yes, challenges persist. But so do the possibilities of redefining success—not just as personal achievement, but as national impact.

A CALL TO ACTION: COME BUILD BHARAT

India is not simply seeking to reverse brain drain. It is seeking to engage its finest minds in its boldest mission—becoming a developed, inclusive, and knowledge-driven nation by 2047.

A national outreach campaign—Come Build Bharat—can invite Indian-origin scientists, technologists, and entrepreneurs to return and co-create. Awards like Bharat Tech Ratna and Deshvaapi Samman can recognise diaspora leaders who build institutions, mentor future scientists, or deliver scalable innovations.

Let their stories be told—in classrooms, media, and museums—not as nostalgia, but as blueprints.

FINAL THOUGHTS: NOT A COMEBACK, BUT A LEAP FORWARD

In the end, the return of talent is not about revisiting the past. It is about building a future bold enough to match our potential. For many Indian-origin professionals, the choice is no longer between comfort and sacrifice—but between relevance and legacy.

History will not remember how many papers we published or how many valuations we chased. It will remember whether we turned India's moment into a movement—whether we had the courage to leap forward, and not just look back.

India is rising. But to rise wisely, deeply, and lastingly—it needs you.

**The author is the former Director of the Agharkar Research Institute, Pune, and a Visiting Professor at the Indian Institute of Technology Bombay. He writes regularly on science, policy, and national development.*



COVER STORY

RITU AAHAAR

Nourishing Health Through Seasonal Wisdom

Health is directly linked to season, as delineated in Ayurveda, and requires a careful adjustment of diet as per seasonal changes



Image Courtesy: Shutterstock




■ Dr Delvin T Robin and
Dr Malavika Das

In Ayurveda, the concept of Ritucharya emphasises the importance of aligning one's diet and lifestyle with the natural changes of the seasons to maintain optimal health and balance among the Doshas. This seasonal regimen guides the selection of specific foods, lifestyle practices, and routines that support the body's inherent rhythms and strengthen its natural defences. By adapting to the unique qualities of each season, Ritucharya not only helps in preventing diseases but also enhances vitality, digestion, and overall well-being.

It also serves as a fundamental guide to understanding Kriya-Kala, which outlines the modes and stages of disease development in relation to the state of Tridoshas according to seasonal changes. A thorough comprehension of this concept is essential for the early diagnosis and prognosis of diseases, enabling the adoption of effective preventive and curative measure.

CLASSIFICATION OF SEASON

In Ayurveda, the year is divided into two solstices: Uttarayana (northern) and Dakshinayana (southern), each consisting of three seasons (Ritus). Uttarayana includes Sisira (winter), Vasanta (spring), and Grishma (summer), while Dakshinayana includes Varsha (monsoon), Sharad (autumn), and Hemanta (late autumn).

Uttarayana /Adana Kala

It signifies the sun's northward movement, a time when the sun and wind exert their maximum influence. This period reduces both the body's vitality and the earth's cooling effect, while increasing the dominance of Tikta (bitter), Kashaya (astringent), and Katu (pungent) tastes, leading to dryness and decreased strength. This phase is characterised by rising warmth and dryness, exerting an overall weakening impact on the environment, including the human body.

Dakshinayana /Visarga Kala

This indicates the descent of the sun or movement of the sun in southern direction. In this period, the wind is not very dry; the moon is more powerful than sun. The earth becomes cool due to the clouds, rain, and cold winds. Unctuousness sets in the atmosphere and Amla (sour), Lavana (salty), and Madhura (sweet) Rasa are predominant, so the strength of a person enhances during this period.

ROLE OF AAHAAR IN MAINTAINING HEALTH

Praninam Punarmulamaharo Balavarnaoujasam Cha highlights that food is the source of strength, complexion, and vitality in all living beings. This underscores the importance of a nutritious diet for good health.

The second half of the 20th century witnessed significant changes in people's diets, characterised by an increased intake of meat, dairy products, vegetable oils, fruit juices, and alcoholic beverages, while the consumption of starchy staple foods like bread, potatoes, rice, and maize flour declined. These dietary shifts suggest that the eating habits and lifestyles of different populations may play a role in influencing the prevalence of cancer and other lifestyle-related disorders, such as obesity, diabetes, and cardiovascular diseases.

Emily R Davenport et al (Department of Human Genetics, University of Chicago) and Samuel A Smits et al (Department of Microbiology and Immunology, Stanford University School of Medicine) studied indigenous populations like the Hutterites and Hadza hunter-gatherers, revealing that the human gut microbiome varies seasonally in both taxa abundance and overall gut microbiome diversity. These shifts are hypothesised to result from seasonal dietary changes, along with less recognised factors such as humidity, temperature, and outdoor exposure, which also fluctu-

EFFECT OF RITUS ON RASA, GUNA, SAREERA AND AGNI BALA

	Ritu					
	Uttarayanam			Dakshinayanam		
Factors	**Sisira**	**Vasanta**	**Grishma**	**Varsha**	**Sharad**	**Hemanta**
Rasa dominance	Tikta (bitter)	Kashaya (astringent)	Katu (pungent)	Amla (sour)	Lavana (salty)	Madhura (sweet)
Guna dominance	Ruksha, laghu, sheeta	Ruksha, sheeta, guru	Ruksha, ushna, laghu	Snigdha, ushna, laghu	Snigdha, ushna, laghu	Snigdha, sheeta, guru
Dosha status	Kapha chaya	Kapha prakopa	Kapha prashama, vata chaya	Pitta chaya, vata prakopa	Pitta prakopa, vata prashama	Pitta prashama
Sareera bala	Maximum	Moderate	Minimum	Minimum	Moderate	Maximum
Agni bala	Maximum	Moderate	Minimum	Minimum	Moderate	Maximum

ate with the seasons.

The human gut microbiota is shaped by seasonal changes and diet, highlighting Ritucharya as a key method to manage the host-microbiota balance. By aligning seasonal diets with the gut's needs, we can foster a healthy microbiome, promoting metabolic well-being and reducing the risk of seasonal infections.

DIET ACCORDING TO EACH RITU

The *rasa*s and properties of food recommended for use in each *ritu*

Sl. No.	Ritu	Rasas	Gunas
1	Sisira	Madhura, Amla, Lavana	Snigdha, Ushna
2	Vasanta	Katu, Tikta, Kashaya	Ruksha, Ushna
3	Grishma	Madhura	Snigdha, Sheeta
4	Varsha	Madhura, Amla, Lavana	Snigdha, Ushna
5	Sharad	Madhura, Tikta, Kashaya	Ruksha, Sheeeta
6	Hemanta	Madhura, Amla, Lavana	Snigdha, Ushna

DIET ACCORDING TO EACH RITU

HEMANTA RITU

Hemanta Ritu is marked by cold winds and chillness. The dominant Rasa is Madhura (sweet), and the primary Mahabhutas are Prithvi and Apa. During this season, a person's strength is at its peak, vitiated Pitta is pacified, and Agni increases.

In Hemanta, it is advised to take Snigdha Aahaar (fatty foods), Vasa (muscle fat), Taila (oil) and Sura (fermented products) from jaggery and foods prepared out of Navamannam (freshly harvested grains), Ikshu (sugarcane), Masha (black gram) and Godhuma (wheat), Takra (buttermilk), Ghrita (cow's ghee) and other Ksheera Vikruti (dairy products). This is supported by the fact that consuming dairy products fermented with beneficial bacteria, such as Lactobacillus, can promote the growth of butyrate-producing microbiota and may also help inhibit the colonisation of pathogens in the gut, thereby reducing the risk of various infections.

During the cold seasons, the gut microbiota undergoes notable shifts resulting in decline of Akkermansia (Verrucomicrobia), while Firmicutes and Actinobacteria increase. Akkermansia is negatively linked to energy extraction, so its reduction facilitates greater caloric uptake. In contrast, Firmicutes enhance both energy absorption and intestinal capacity, aided by high-fat and sugary diets that suppress Akkermansia and promote Firmicutes, Mollicutes, and Eubacterium, key producers of short-chain fatty acids (SCFAs) like butyrate and propionate.

SCFAs support gut health by promoting IL-10, suppressing inflammation, activating Tregs, and strengthening the intestinal barrier. Since most butyrate producers are Firmicutes, their abundance is crucial for immune regulation.

Madhura (sweet), Amla (sour), and Lavana (salty) foods, including Nava Odana (new rice), Audaka (meat of aquatic animals), Anupa Mamsa (meat of animals from marshy land) and Ushna Thoya (hot water) are recommended.

Avoid light (Laghu), cold, and dry foods that aggravate Vata, as well as cold drinks.

SISIRA RITU

Sisira Ritu, marked by cold weather and brisk winds, dominated by Tikta (bitter) taste, Vayu and Akasha Mahabhuta. It leads to decreased strength, accumulation of Kapha Dosha and higher state of Agni.

Foods with a strong Amla (sour) flavour are preferred, including cereals and pulses like Godhuma (wheat), gram flour, new rice, and corn. The diet should feature ginger, garlic, Haritaki (Terminalia chebula), Pippali (Piper longum), sugarcane products, and dairy.

Avoid foods with Katu (pungent), Tikta (bitter), or Kashaya (astringent) tastes, as well as light (Laghu) and cold (Shita) foods.

VASANTA RITU

Vasanta Ritu is the season of flowering and new leaves. The dominant *rasa* is Kashaya (astringent) and the Mahabhutas are Prithvi and Vayu. During this time, strength is moderate, Kapha Dosha vitiates, and Agni remains weak.

For optimal health during this period, the diet should focus on easily digestible foods, with a preference for old Yava (barley), Godhuma (wheat), rice, and other cereals, along with meat of Jangala Desha animals and fermented drinks. Foods with Tikta (bitter), Katu (pungent), and Kashaya (astringent) tastes are recommended. Including honey in the diet can be beneficial, and easily digestible meats are suitable. Additionally, the intake of Sringaverambu (water boiled with Zingiber officinalis), Madhuambu (water mixed with honey) and Sarambu (water boiled with Pterocarpus marsupium) are recommended.

It is advised to avoid heavy, Sheeta (cold), Snigdha (viscous), and Amla (sour) or Madhura (sweet) foods, as well as new grains, curd, and cold drinks.

GRISHMA RITU

Grishma (summer) is marked by intense heat, and dry, unhealthy winds. Dominant *rasa* is Katu (pungent), with Agni and Vayu as Mahabhutas. Strength decreases, Vata Dosha accumulates, while vitiated Kapha Dosha is pacified. Agni remains mild.

Foods with Madhura (sweet), Snigdha (unctuous), Sheeta (cold), and Drava (liquid) Guna are indicated. Sheeta Mantha with sugar, Jangala Mamsa (meat of animals in arid locales), Shaliannam along with Grita and milk should be consumed. Polished Shali rice is paired with meat of Jangala Desha animals. Light meat soup (Rasa), Rasala, Raga, and Khandava, along with Pancasaram (a sour soft drink made with banana and jackfruit slices in a clay pot), are recommended. Consuming these foods can promote the growth of bacteroides

DRUGS USED IN PATHILA THORAN				
Local Name	**Sanskrit Name**	**Botanical Name**	**Family**	**Part Used**
Thazhutama	Punarnava	Boerhavia diffusa Linn.	Nyctaginaceae	Leaves
Chembu	Dalasarini	Colocasia esculenta (L.) Schott	Araceae	Leaves
Cheera	Palakya	Spinacia oleracea	Amarantaceae	Leaves
Tagara	Chakramarda	Cassia tora Linn	Caessalpiniaceae	Leaves
Payar	Nishpava	Vigna unguiculata (L.) Walp	Fabaceae	Leaves
Choriyanam	Dusparsaka	Tragia involucrata L.	Euphorbiaceae	Leaves
Chena	Surana	Amorphophallus companulatus Blume	Araceae	Leaves
Kumbala	Kushmanda	Benincasa hispida (Thunb.) Cogn.	Cucurubitaceae	Leaves
Mattan	Pita Kushmanda	Cucurbita maxima Duchesne ex Lam.	Cucurubitaceae	Leaves
Vellari	Trapusa	Cucumis sativus L	Cucurubitaceae	Leaves

(Bacteroidetes phylum), polysaccharide utilisers, and saccharolytic species like bifidobacterium and ruminococcus that thrive on carbohydrates.

Whole grains, rich in resistant starch, oligosaccharides, and non-digestible carbohydrates, support Prevotella, Xylanibacter, and Treponema, which ferment substrates like carboxymethylcellulose, xylene, and xylose to produce SCFAs (short chain fatty acids). In the Hutterite population, bacteroidetes with abundant carbohydrate-active enzymes (CAZymes) increased during summer, correlating with higher fruit and vegetable intake.

Patala Vasitham Amba (cool water flavoured with trumpet flower and camphor powder) also makes a refreshing drink. Milk with sugar candy is to be consumed before going to bed and Sasankakirana prepared with Talisacurna, sugar candy, and camphor.



VARSHA RITU

Varsha Ritu is characterised by cloudy skies and rains without thunderstorms. Dominant Rasa is Amla (sour), with Prithvi and Agni as Mahabhutas. Strength decreases, Vata Dosha vitiates, Pitta Dosha accumulates, and Agni becomes disturbed.

During this season, consume whey (Mastu) mixed with Sauvarcala (sochal salt) or Pancakola powder, along with boiled rain or well water. Advice: Ksaudranvita Aahaar (one should generally use honey in preparing diets, drinks and others). Honey, rich in fructose, glucose, and fructo-oligosaccharides, serves as a favourable substrate for bifidobacteria. Shamala et al report a significant increase in lactic acid bacteria in the intestines of honey-fed rats, indicating its potential to modify the gut microbiota. This rise in Lactobacillus and Bifidobacteria populations promotes health through short-chain fatty acid (SCFA) production, immune stimulation, inhibition of pathogens, and support of beneficial microbes.

If the days are cooler due to heavy rains with storms, one should take such of the diets as are Amla (sour), Lavana (salty) and Sneha (unctuous); this serves to counteract the vitiation of Vata during this season. In order to maintain normal digestion strength, one should take Purana Yava (old barley), Godhuma (wheat) and Shali (rice) and Jangala Mamsa (meat of animals from arid region) and it should be processed with Yusha (vegetables soup). Mahendra Jala (Pure rain water), Kaupa Jala (water from the well or pond), Taptashita Jala (boiled and cooled) mixed with little honey should be consumed.

SPECIAL DIETARY PRACTISES IN KERALA AS A PART OF VARSHA RITUCHARYA

Karkkidaka, the last month of Malayalam calendar, coincides with the arrival of the southwest monsoon in Kerala. From an Ayurvedic perspective, this month falls under the Varsha Ritu, or rainy season, a time when the body's strength (Sarira Bala), digestive power (Agni Bala), and immunity are notably weakened. The seasonal shift during this period increases susceptibility to illnesses, especially for those who neglect proper diet and lifestyle practices.

Diets like Karkidaka Kanji, Mukkudi and Pathila Thoran are practiced

INGREDIENTS USED IN MUKKUDI				
Local Name	**Sanskrit Name**	**Botanical Name**	**Family**	**Part Used**
Muthil	Mandukaparni	Centella asiatica. (L.)	Apiaceae	Juice of leaves
Puliyarila	Changeri	Oxalis corniculata L	Oxalidaceae	Juice of leaves
Kutakappalayari	Kutajabeeja	Holarrhena antidysenterica (L.) Wall. ex A. DC	Apocynaceae	Seed
Kurumulaku	Marica	Piper nigrum L.	Piperaceae	Fruit
Kottambalayari	Dhanyaka	Coriandrum sativum Linn	Umbelliferae	Seed
Jeeraka	Jeeraka	Cuminum cyminum Linn	Umbelliferae	Seed
Chukku	Sundi	Zingiber officinale Roscoe	Zingiberaceae	Rhizome
Uluva	Methika	Trigonella foenum-graecum Linn	Fabaceae	Seed
Manjal	Haridra	Curcuma longa L	Zingiberaceae	Rhizome
Moru	Takra	Buttermilk		

as a part of Karkidaka Masacharya to counter these effects.

KARKIDAKA KANJI

Kanji (Yavagu) is a traditional diet in Kerala, considered Satmya (suitable), and is Deepaka (stimulate digestive fire), Pachaka (aids digestion), and Anulomaka (facilitates downward movement of *vata*), promoting digestion and nourishment. In Karkidaka Kanji, a number of herbs are processed along with rice. The combination varies according to the regional availability of the herb. The herbs used are Balya (promotes strength and immunity), Deepaka (stimulates digestive fire), Pachaka (digestive), and Vatahara (*vata*-pacifying), beneficial for conditions like Kshut (hunger), Trushna (excessive thirst), Glani (Fatigue), Dourbalya (weakness), Kukshiroga (abdominal disorders), and Jwara (fever).

PATHILA THORAN

Pathila Thoran is a side dish made from fresh leaves of 10 local herbs, rich in Pitta Anilahara (pacify *pitta* and *vata*), Deepaka (stimulates digestive fire), Pachaka (digestive), Ruchya (enhances taste), and Balakara (strength promoting) properties. Leafy vegetables used in it are high in antioxidants, vitamins, minerals, proteins, and fibre, boosting immunity.

MUKKUDI SEVA

Mukkudi Seva involves the consumption of medicated buttermilk. This probiotic-rich drink enhances gut health, improves digestion, and alleviates common seasonal digestive issues. Additionally, Mukkudi is believed to help regulate cholesterol and strengthen the immune system. All of these serve as Aahaar (food) and Pathya (healthy diet), aiding digestion, enhancing immunity, and preventing common rainy-season ailments making them simple, seasonal rejuvenation foods.

SHARAD RITU

Sharad Ritu (autumn) is marked by bright sun, clear skies with occasional white clouds, and wet earth. Dominant Rasa is Lavana (salty), with Apa and Agni as Mahabhutas. Strength is moderate, vitiated Vata Dosha pacifies, Pitta Dosha vitiates, and Agni increases.

During this season, consume foods with Madhura (sweet) and Tikta (bitter) flavours, along with light (Laghu) and cold (Sheeta) properties. Recommended foods include Shali (rice), Godhuma (wheat), Mudga (green gram), Sita (sugar candy), Dhatri (Gooseberry), Madhu (honey), Patola (Trichosanthes diocia), Jangala Mamsa (dry land animal meat).

Avoid hot, bitter, sweet, astringent foods, as well as fats, oils, aquatic animal meat, and curds.

RITU-SANDHI CHARYA

Ritu-Sandhi is a 14-day transitional period between two seasons, during which one should gradually withdraw from the practices of the preceding season and progressively adopt those of the upcoming one. This includes adjustments in diet, lifestyle, and behaviour.

Abrupt changes can be challenging, so a stepwise approach is recommended. For example, during the transition from Varsha Ritu (monsoon) to Sharad Ritu (autumn), it is advisable to slowly reduce foods rich in Katu Rasa (pungent) and Amla Rasa (sour), which aggravate Pitta *dosha*. Gradual moderation during Ritusandhi supports smoother adaptation and better health.

CONCLUSION

Tasya Shitadiya Ahaarbalam Varnascha Vardhate/ Tasyartusatmayam Vaditam Chestaharvyapasrayam, which means 'the strength and complexion of the person knowing the suitable diet and regimen for every season and practicing accordingly are enhanced, it highlights the significance of tailoring one's diet and lifestyle to seasonal changes.

Adopting Ritucharya offers a valuable opportunity to harmonise the dynamics of the human gut flora, helping to protect the host from seasonal variations and other diverse factors. Strict adherence to seasonal regimens and the inclusion of seasonal foods can modulate the gut microbiome, fostering an environment that supports optimal health.

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Securing India's Industrial Backbone

Cybersecurity for Operational Technologies

As one of the world's largest economies that also supports a digitally empowered society, India needs to secure its system of industrial control technologies on priority

As India forges ahead with its ambition to become a $5 trillion economy and a digitally empowered society, the focus on cyber resilience has never been more critical. At the heart of this transformation lies Operational Technology (OT)—the system of industrial control technologies that monitors and controls critical physical infrastructure. From power grids and oil refineries to transportation networks and smart cities, OT systems form the silent backbone of India's modern economy. However, as these systems become increasingly integrated with digital networks, they face an escalating risk of cyber threats.



■ Dr Udaya Shankar Puranik

Ensuring the cybersecurity of Operational Technology is not only a matter of technological readiness but also of national sovereignty, economic stability, and public safety.

OPERATIONAL TECHNOLOGY: THE CRITICAL LAYER

Operational Technology (OT) refers to hardware and software systems that interact with the physical world to manage processes in real-time. These include:

• Supervisory Control and Data Acquisition (SCADA) systems

Image Courtesy: Shutterstock

• Distributed Control Systems (DCS)
• Programmable Logic Controllers (PLCs)
• Building Automation Systems (BAS)

Unlike Information Technology (IT), which handles data storage and communication, OT deals with real-world operations such as regulating electricity flow, controlling manufacturing lines, or managing transportation signals.

OT systems are foundational to India's critical infrastructure sectors:

• Power generation and distribution
• Oil and natural gas
• Railways and metro transport
• Smart city management
• Manufacturing and defence production
• Water and wastewater management

The convergence of IT and OT, driven by desires for increased efficiency and visibility, has dissolved traditional 'air gaps', exposing previously isolated OT systems to IT-borne threats and significantly expanding the overall attack surface. Similarly, the rapid proliferation of IoT (Internet of Things) and IIoT (Industrial Internet of Things) devices introduces a substantial 'security debt' into OT environments, as many of these devices are designed with inadequate security and are difficult to update, creating persistent vulnerabilities.

The adoption of cloud computing in OT, while offering scalability and advanced analytics, further complicates security by dismantling traditional isolation strategies and introducing complex shared responsibility models.

WHY OT CYBERSECURITY IS A NATIONAL IMPERATIVE

The consequences of cyberattacks on OT can be devastating. More than data theft, these attacks can lead to physical damage, long-term economic paralysis, and public endangerment. The rationale for prioritising OT cybersecurity in India includes:

1. Economic Security

Industrial operations account for a significant portion of India's GDP. A cyberattack on a major thermal power station or port can cascade through the supply chain and affect trade, productivity, and consumer services.



Image Courtesy: Twitter

2. Public Safety

Malicious manipulation of systems managing chemical plants, transport signalling, or power grids can result in disasters that mirror acts of war or terrorism in scale.

3. Strategic Sovereignty

Cyber warfare has emerged as a fifth domain of warfare. India's adversaries could exploit unprotected OT networks to degrade critical capabilities in times of conflict.

4. Digital India's Foundation

Initiatives like Digital India, Make in India, Smart Cities, and PM Gati Shakti are OT-intensive and depend on reliable, secure operations of cyber-physical systems.

CURRENT LANDSCAPE IN INDIA

India has made commendable progress in recognising the significance of OT cybersecurity. Notable developments include:

• Creation of the National Critical Information Infrastructure Protection Centre (NCIIPC)
• Sectoral cybersecurity guidelines by ministries (e.g., power, oil & gas)
• Initiation of cyber audits and tabletop exercises in key PSUs
• Development of sector-specific CERTs (Computer Emergency Response Teams)

Public and private utilities have begun establishing OT-specific Security Operations Centres (SOCs) and incident response protocols. However, challenges remain:

• Many facilities still operate legacy systems with obsolete software.
• Smaller utilities and municipalities lack cyber maturity.
• The policy-to-practice gap is visible in weak enforcement and limited testing.
• There is often no single point of accountability for OT security within organisations.

THE EXPANDING THREAT LANDSCAPE

India's OT landscape is under increasing pressure from both sophisticated adversaries and opportunistic cybercriminals. Emerging trends and threats include:

1. Ransomware in ICS Environments

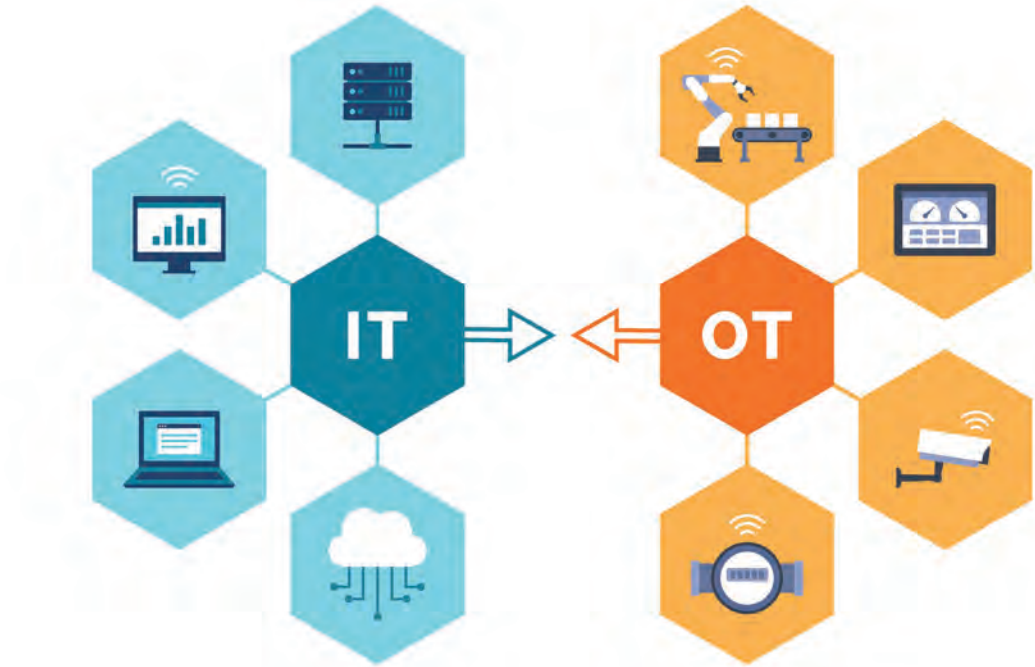
Cybercriminals now target control systems to extort organisations by threatening shutdowns or data corruption. Some variants are designed to jump from IT to OT networks via shared interfaces.

2. State-Sponsored Attacks

Adversarial nations or groups may infiltrate OT systems to pre-position malware capable of being triggered during conflict. The objective may be silent reconnaissance or building "kill switches" in power, oil, or transport infrastructure.

3. Insider Threats

Due to lack of background checks or poor access controls, internal em-



ployees, vendors, or contractors may inadvertently—or intentionally—enable breaches.

4. Remote Work and Pandemic Residue
Post-COVID, many control systems enabled remote access. In many cases, security controls were added hastily, creating long-term vulnerabilities that persist today.

5. AI-Powered Attacks
Attackers now use AI to mimic normal industrial traffic, making detection more difficult. Sophisticated malware can "learn" system patterns before launching targeted manipulation.

6. Tool Proliferation on the Dark Web
Sophisticated ICS-targeting toolkits such as TRITON and INDUSTROYER have been reverse-engineered and are widely available, lowering the barrier for cyberattacks even from non-state actors.

INDIA'S OPPORTUNITIES IN OT CYBERSECURITY

India can convert these vulnerabilities into an opportunity for leadership:

1. Domestic Innovation Ecosystem
Encouraging Indian cybersecurity startups to build indigenous OT threat detection, monitoring, and control solutions compatible with our infrastructure can reduce import dependence.

THE ROAD AHEAD: STRATEGIC RECOMMENDATIONS

India must move toward a unified, proactive, and resilient OT cybersecurity framework. Recommended strategic pillars:

Pillar	Recommendation
Governance	Empower NCIIPC and CERT-In to issue binding directives with measurable metrics for critical sectors.
Resilience Testing	Make cyber risk assessments and incident response drills mandatory for all critical infrastructure operators.
Digital Twins	Use simulation environments (digital twins) to model attack vectors and test defences in a sandboxed OT setting.
Standardisation	Develop an Indian standard based on IEC 62443 and NIST 800-82, contextualised to Indian sectors and threats.
International Partnerships	Collaborate with cyber-advanced nations like Israel, Japan, Germany for joint threat intelligence and tool development.

2. Unified Public-Private Platform
A national OT Cybersecurity Mission could create a formal collaboration channel between PSUs, private sector, academia, and law enforcement for real-time threat sharing and joint defence exercises.

3. Workforce Development
India must build a specialised cadre of OT cybersecurity professionals. This includes:
- Including ICS/SCADA security in engineering syllabi.
- Launching vocational training modules for plant technicians and SCADA operators.
- Upskilling existing IT staff in control system security through national skilling platforms.
- Creating cyber apprenticeships embedded in industrial internships.

AICTE and UGC, in collaboration with NASSCOM and NSDC, can play a pivotal role in scaling such capacity-building programmes.

4. R&D and Academia
Government can invest in setting up National Centres of Excellence for Industrial Cybersecurity—focusing on real-time testbeds, hardware security, and threat modelling.

5. Exporting Cybersecurity Services
India's cybersecurity service providers can support OT resilience across Southeast Asia, Africa, and Middle East—regions facing similar digitisation challenges.

Image Courtesy: Pexels

CHALLENGES UNIQUE TO INDIA

Despite its IT prowess, India faces distinct challenges in OT security:

1. Diversity and Age of Systems

Many Indian industrial facilities use a mix of old and new equipment. This "brownfield" nature complicates patching, standardisation, and integration with modern security tools.

2. Lack of Shared Taxonomy

Different sectors define threats, risk levels, and mitigation plans differently. A national glossary and grading system can aid uniform implementation.

3. Funding Constraints

While large corporations invest in cyber defence, state utilities and smaller cooperatives struggle with financial limitations and rely on outdated firewalls or antivirus tools.

4. Vendor Ecosystem Risk

OEMs and service vendors often access OT environments for diagnostics and upgrades. Without rigorous vetting, this supply chain becomes a critical vulnerability.

5. Digital Literacy at the Operator Level

Cyber awareness at the floor level in control rooms and substations is low. This human gap could nullify even the most advanced technical protections.

MARKET POTENTIAL FOR OT CYBERSECURITY IN INDIA

A Growing Multi-Billion Dollar Market

India's overall cybersecurity market is projected to reach $9.8 billion by 2027, growing at a CAGR of 19–21% (source: Nasscom-DSCI, IDC). The OT cybersecurity segment is a fast-growing subset of this market, driven by investments in:

- Power grid modernisation (smart grids)
- Smart manufacturing under Industry 4.0
- Smart cities (100+ in progress)
- Metro rail and rapid transport systems
- Oil, gas and chemical plant automation
- Defence production corridors

SECTOR-WISE DEMAND

Sector	Investment Driver	OT Security Market Opportunity (2025–2030)
Power & Energy	Smart grid rollout, renewable integration	Rs 4,000+ crore
Oil & Gas	Pipeline digitisation, refinery modernisation	Rs 3,500+ crore
Railways & Transport	Metro signalling, Gati Shakti logistics plan	Rs 2,000+ crore
Smart Cities	Smart command centres, public utility automation	Rs 2,500+ crore
Defence & Aerospace	Strategic deterrence, digital command systems	Rs 3,000+ crore

Conservatively, OT cybersecurity is expected to contribute 15–20% of the total industrial cybersecurity market by 2027, potentially exceeding Rs 12,000–15,000 crore (~$1.5–1.8 billion).

JOBS POTENTIAL IN OT CYBERSECURITY

Demand-Supply Gap

According to NASSCOM, India will need over 1 million cybersecurity professionals by 2026, and a significant share (~20%) will be required for OT and critical infrastructure security.

Currently, India has a shortage of OT-specific cyber talent, creating a high demand for:

- Industrial control system (ICS) security experts
- SCADA/PLC/IoT penetration testers
- OT network architects and analysts
- Incident responders for industrial environments
- Security engineers with experience in power/oil domains

Beyond Technology: Building a Cyber-Resilient Culture

True resilience is not achieved through technology alone but by building an organisational culture rooted in cyber awareness and operational discipline.

- Appoint Chief OT Security Officers in major PSUs and smart cities.
- Foster incident transparency—share what went wrong and how it was fixed.
- Conduct gamified learning modules for operators.
- Recognise and reward employees who report vulnerabilities or suspicious activities.

Cybersecurity must become as integral to plant operations as safety protocols and standard operating procedures.

CONCLUSION: INDIA AT A STRATEGIC CROSSROADS

India's journey toward becoming a global economic and technological power is deeply dependent on the security of its industrial operations. Cybersecurity for Operational Technology is not a luxury—it is a necessity.

The scale and complexity of the challenge is immense. Yet, India is uniquely positioned—with a vast engineering talent pool, rising digital economy, and strong public institutions—to lead the global discourse on OT cyber resilience.

As we lay down smart grids, metro systems, 5G towers, and digital factories, we must lay down stronger cyber foundations too. The hour calls for vision, investment, and urgency.

India must not only protect its infrastructure but use its learnings to build and export a model of OT security suited for the Global South.

To borrow the words of former President Dr A P J Abdul Kalam:

"You have to dream before your dreams can come true."

The dream: a secure, resilient, and empowered Bharat, where progress and protection walk hand in hand.

**The writer has 37 years' global experience in IT and is presently Director, AI, Theta Dynamics, Bengaluru.*



Image Courtesy: Pixabay

SCIENCE & SPIRITUALITY

A Scientific Perspective on the Healing Power of Bhakti Yoga

The synergy of traditional practices and connected science underscores a harmonious approach to health in Indian culture, blending time-honored wisdom with contemporary understanding



■ **Prof Neera Raghav**

I felt overwhelmed and privileged on receiving the invitation to deliver a talk at the 8th International Gita Seminar, at Kurukshetra University, Kurukshetra, on the sub-theme: 'Strategies for sustainable global wellness in the realm of Shrimad Bhagwat Gita'. I have long aspired to seize this opportunity since the University has been organising the event on the Gita Jayanti Samaroh, However, this invitation opened the doors for me to explore the *Bhagavad Gita* scientifically. Earlier, I used to relate this to philosophy and spirituality. While focusing on the topic, 'The Bhagavad Gita: Scientific Ancient Wisdom for Modern Time Well-Being', I found that well-being is related to Trigunas of Prakriti and the food, i.e., Satvik, Rajsik, and Tamsik (*Bhagavad Gita*, 14.5); balancing the body and mind in all situations i.e. *Yogasth Kuru Karmani* (*Bhagavad Gita*, 2.48)

sattvam rajas tama iti gunah prakriti-sambhavaha |

nibadhnanti maha-baho dehe dehinam avyayam || BG 14.5 ||

yoga-sthah kuru karmani sangam tyaktva dhananjaya |

siddhy-asiddhyoh samo bhutva samatvam yoga uchyate || BG 2.48 ||

Since I aimed to explore a field distinct yet still intertwined with science, I further delved into the subject and explored that Bhakti Yoga not only provides profound insights into connecting with 'The Divine' but also plays a significant role in enhancing the practitioner's overall well-being. Popularising the techniques of Bhakti Yoga benefitted the society for spiritual growth as well as enhanced their physical and mental health.

The term 'Bhakti' does not explicitly exist in the Vedas, yet the verses expressing reverence, love, and worship towards deities and the divine are very well there. The verse (*The Rigveda*, 1-89-1) expresses faith and requests for their favor.

a no bhadrah kratavo yantu visvato dabdhaso aparitasa udbhidah |

deva no yatha sadam id vrdhe asann aprayuvo raksitaro dive-dive || RV1-89-1||

The term Bhakti was more visible fully in later texts like *Shreemad Bhagwad Mahapuran*, the *Ramayan* and the *Bhagavad Gita*. The known pathways of Bhakti were first best described as 'Navavidha Bhakti' by Bhakt Prahlad in *Shreemad Bhagwad Mahapuran* (7.5.23-24), while responding to his father Hiranyakashyappu's question what he learned from his teacher.

Sravanam kirtanam visnoh smaranam pada-sevanam |

arcanam, vandanam dasyam sakhyam atma-nivedanam || BP7.5.23 ||

iti pumsarpita visnau bhaktis cen nava-laksana |

kriyeta bhagavaty addha tan manye dhitam uttamam || BP7.5.24 ||

Navavidha Bhakti describes nine paths, which are listening to songs or texts or *satsang* (Shravanam), singing in groups (Kirtanam), remembering (Smaranam), providing service in temple or to the idol (Padsevanam), worshiping (Archanam), praising (Vandanam), servitude (Dasyam), considering God as friend (Sakhyam) and surrender to God (Atamnivedam).

These can be grouped in three broad categories, depending upon the practices involved. Shravanam, Kirtanam and Archanam are related with music; Padsevanam, Dasyam and Sakhyam are connected with love and compassion (Karuna) whereas Smaranam, Vandanam and Atamnivedam are associated with the belief that everything will be taken care of by 'THE DIVINE' and in medical terms, 'The placebo effect comes into mind'.

In all these prescribed practices, we find that there is an increase in feel-good hormones (serotonin, gamma amino butyric acid, oxytocin, and endorphins), balancing the dual mode hormones (dopamine and epinephrine), and a decrease in feel-bad hormones which are associated with anxiety and the related disorders (cortisol and testosterone).

MUSIC THERAPY AND HORMONE LEVELS

Music modulates the levels of various hormones and affects the physiological and psychological states having direct implications for therapeutic interventions, particularly in stress-related disorders like anxiety and depression, which indirectly affect conditions related to heart, diabetes, and digestive disorders. Oxidative stress is even found related to oncology.

Serotonin enhances mood and memory, reduces anxiety, and improves overall emotional well-being. GABA also treats anxiety disorders. Music therapy enhances both serotonin and GABA levels, promoting relaxation and reducing anxiety symptoms. Calm music helps reduce excessive sympathetic activity and adrenaline levels in patients with anxiety or hypertension. Dopamine can address conditions related to mood disorders, neurodegenerative diseases, and movement disorders. This shows promise in improving motor function and emotion-

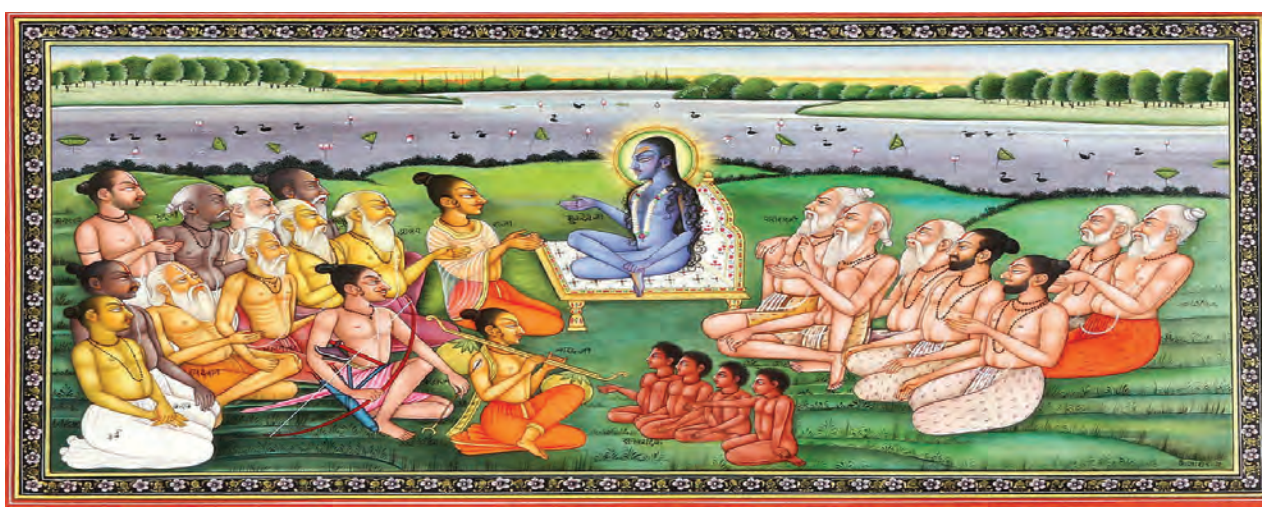


Image Courtesy: Exotic India Art

A painting depicting Mahamuni Shukadeva narrating *Bhagavata Purana* to Raja Parikshata

al well-being in context with Parkinson's disease, a neurodegenerative disorder characterised by dopamine deficiency. Dopamine release enhances mood with positive emotional control and thus is helpful in the treatment of depression and anxiety. Oxytocin, a peptide, plays an important role in social bonding and is found in increased concentration in group singing or the Kirtans. Music induces transformative changes in the brain by restructuring neural networks and developing neuroplasticity. It also enhances cognitive functions and brings physical well-being.

During Shravanam, the auditory stimulus is transmitted via vibrations of air, and transduced electrical impulses through the internal ear to the brain for encoding by various neural networks. Contrary to the passive act of Shravanam, reciting *bhajanas* / *mantras* during Archanam is an active performance having precise control in the method of worship that requires motor execution. Motor control requires proper timing, sequence, and spatial chanting of words associated with rhythmic architecture along with the auditory perception route. Kirtanam, on the other hand, involves singing *bhajans* / chanting *mantras* and dancing in groups that invoke the feeling of social bonding and the related hormone oxytocin.

Oxytocin plays an important role in social bonding and is found in increased concentration in group singing or Kirtans. Music induces transformative changes in the brain

CLAPPING IN RHYTHM WITH MUSIC IN BHAJANS AND KIRTANS

Clapping performed consciously involves specific muscles and activates the cortical region of the brain. These accompanying acclamations for the salutation of the divine, during the Shravanam, Kirtanam, and Archanam forms of Bhakti, have established the release of endorphins which are natural painkillers and mood boosters. According to an article in *The Times of India* dated 14 September 2024, clapping in the *bhajans* (devotional songs) is surprisingly beneficial for health. This rhythmic act activates acupressure points, improves blood circulation, calms the mind, and boosts energy. Feelings like anger, stress, anxiety, and despair are replaced by feelings of enthusiasm and pride with the release of dopamine. Clapping not only releases endorphins but also increases blood flow and tones muscles. It improves timing and rhythmic skills and helps in the coordination of different muscle groups of hands, arms, shoulders, and chest, and improves the motor skills of the person. Rhythmic movements with associated music activate the subconscious mind, improving brain functions, ultimately affecting the health of the individual.

DANCING ON THE RHYTHMS OF BHAJANS AND KIRTANS

Dancing is a well-known, full-body workout that engages a variety of muscle groups. Even the basic forms of dance styles involve muscles of the ankle, calf, hip, back, arms and shoulders that can improve muscle tone, flexibility coordination, and overall

KINDNESS AND COMPASSION IN SERVITUDE, AND RELATED HORMONES

Helping others fosters meaningful connections that can lower the chances of heart disease, stroke, and lead to overall decline in daily tensions. Offering support to someone in distress can also provide a fresh perspective and momentarily shift focus from personal worries. Serving enhances social bondage and persuades kindness. The neuroscience of kindness reveals that acts of compassion activate specific regions of the brain which are associated with reward, empathy, and pleasure, leading to the release of neurotransmitters like serotonin and dopamine. These practices involve a sense of community and belongingness that significantly benefit psychologically and also promote emotional healing and resilience.

Sakhya Bhav: Considering the divine as your friend is the meaning of Sakhya Bhav of Bhakti Yoga. Friendship, a form of compassion, is also related to the faith that someone is there for you in need and support. There are reports where the feeling of friendship is related to feel-good hormones.

Friendship is deeply intertwined with hormones like dopamine, oxytocin, and serotonin, that play a crucial role in building and maintaining social connections. A powerful cocktail of oxytocin, dopamine, and serotonin is enhanced



Image Courtesy: Wikimedia Comons

Sri Chaitanya Mahaprabhu, who was born in 1486, is shown performing 'Nagar Kirtan', or devotional chanting and dancing, in Nabadwip, Bengal

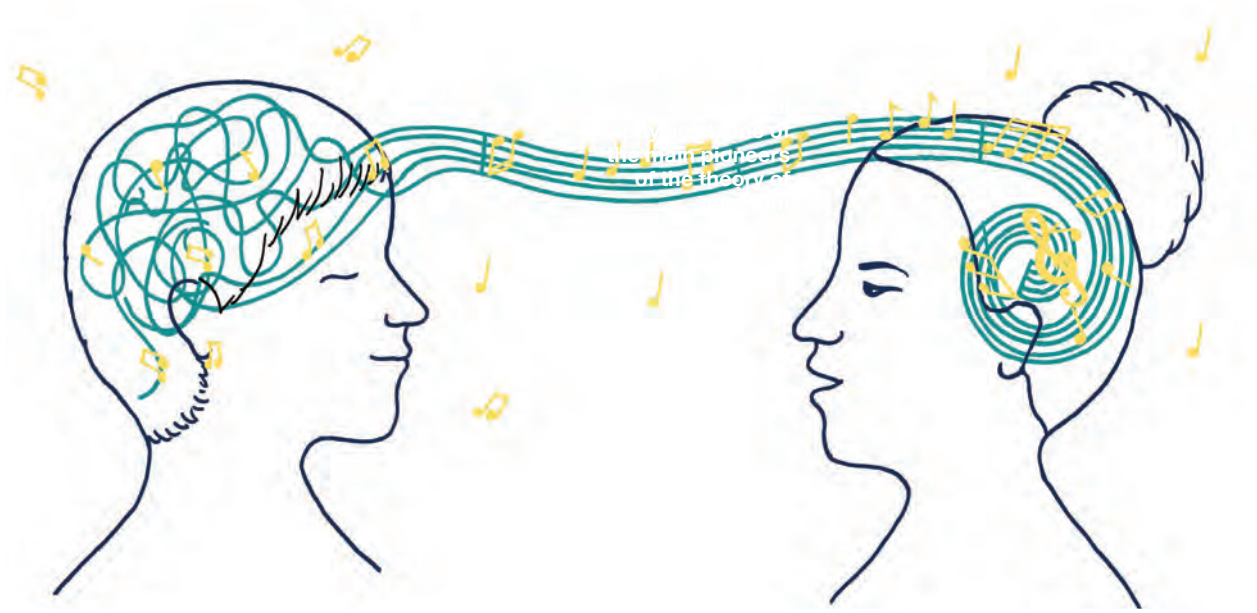


Image Courtesy:Freepik

with the decrease in testosterone and cortisol levels. Laughing, sharing feelings, engaging in conversations, help release serotonin and dopamine, and oxytocin. In the moments of tears, the hormone prolactin is released which results in calmness. Lower testosterone and cortisol levels have been found associated with increased feelings of closeness.

Recent studies revealed situations like Jadu Ki Jhappi, Holding Hands, Reward Ki Thapki directly activate parts of the insula (hidden regions of the brain), thereby evoking pleasant feelings by regulating emotional, hormonal, and affiliated responses to these personalised attentions between individuals. Friendship shares common CNS features with love but shows distinct neural and neuro-anatomical activity patterns that are different to compassion.

PLACEBO EFFECT AND BHAKTI YOG

Vandan, Smarnam, and Atmanivedam relate with the faith where the modern world's term Placebo effect comes into the picture. The placebo is the faith given to the patient that they are under treatment. It is used to establish the pharmacological effect of most of the drugs before their approval as medicine. The power of the placebo effect was published by *Harvard Health Publishing*, on 22 July 2024. The placebo group is given a neutral compound which is not a drug but they are unaware of this fact. Merely believing that they are on a drug, the patient gets better and the effect is known as the placebo effect. The report mentions 'the mind' as a powerful healing tool. The act of placebos leads to increased levels of endorphins and dopamine after a complex neurobiological reaction in specific regions of the brain that are linked to moods, emotional reactions, and self-awareness, finally leading to therapeutic benefit. Placebos include all the rituals of treatment starting from going to the clinic, the examination by medical professionals in white coats, and the entire environment that assures that the patient is on medication. Similar to the placebo effect, Atmanivedan, Smarnam and Vandan assure the devotee that they are being taken care of by the divine. Placebo has been found to work even when the patients know that the drug they are taking is fake (placebo) as per a report published in *Science Translational Medicine*. The act of taking the pill resulted in 50% affectivity in a known placebo group of migraine patients. Isn't it surprising that just the act of taking the pill even after knowing that it is fake has the healing power! This is what happens to devotees who follow rituals like Atmanivedan, Smarnam, and Vandan.

The synergy of traditional practices and connected science underscores a harmonious approach to health in Indian culture, blending time-honored wisdom with contemporary understanding. The practices of Bhakti Yoga are intertwined with the wellness of the practitioner. The power of Bhakti Yoga not only harnesses the mindfulness and inner strength of the devotee but also directs them on the path of well-being, happiness, and a blissful life.

Similar to the placebo effect, Atmanivedan, Smarnam and Vandan assure the devotee that they are being taken care of by the divine. Placebo has been found to work even when patients know that the drug they are taking is fake

**The writer is a Professor in the Department of Chemistry, Kurukshetra University, Kurukshetra. She believes in the holistic way of teaching and has a strong inclination towards Indian Traditional Knowledge.*

SPOTLIGHT: DR SAROJ GHOSE (1 SEPTEMBER 1935-17 MAY 2025)

A Visionary of Science Communication and Museum Innovation

With his path breaking initiatives, Dr Saroj Ghose revolutionised informal science education in the country, while simultaneously creating a robust infrastructure of science museums



■ Dr Shivaprasad Khened



Dr Saroj Ghose

Dr Saroj Ghose, the visionary behind India's post-Independence museum movement in general and science museum movement in particular, and a luminary who left an indelible mark in science communication and on the scientific and cultural landscape of India, passed away on the noon of 17 May 2025, in Seattle, USA. He was 89. His contributions to the National Council of Science Museums (NCSM), which he served as the founder Director General (1986-1997), and to the global museology, including his two term presidency of the International Council of Museums (ICOM), remain monumental. Even in death, Dr Ghose exemplified his lifelong dedication to science, bequeathing his body to a medical hospital for research, a poignant reflection of his lifelong practice and unwavering commitment to science.

EARLY LIFE IN SCIENCE MUSEUMS AND RISE TO THE LEADERSHIP

Born on 1 September 1935, in Calcutta, Dr Ghose demonstrated his academic brilliance early in life. A prodigious student at school, he graduated in Electrical & Control Engineering from



Dr Saroj Ghose (centre) at an event with then Indian Prime Minister Rajiv Gandhi (second from right)

the Jadavpur University, Calcutta. This was the time when India's public sector industries offered the best of opportunities and remuneration to engineers. Dr Ghose chose an unconventional path and joined the Birla Industrial and Technological Museum (BITM) as a Junior Technical Officer in 1958.

BITM, the mother institution for NCSM, was modelled on the Deutsches Museum, Munich, Germany. It was developed under the patronage of Dr BC Roy, the Chief Minister of West Bengal, with philanthropic support from Ghanshyamdas Birla, an industrialist, and Jawaharlal Nehru, India's first Prime Minister. BITM, which opened on 2 May 1959, was developed by the Council of Scientific and Industrial Research (CSIR) under the leadership of Amalendu Bose, who later became Director Museums (CSIR) and founder Director NCSM. BITM played a key role in the formation of NCSM, an institution which Dr Ghose served for nearly four decades. Dr Ghose quickly rose through the ranks of BITM, taking on the role of Director NCSM in 1979 and DG NCSM from 1986 -97.

Dr Ghose obtained an MS in Control Engineering from Harvard University, USA, in 1964, and his PhD from Jadavpur University in 1974, for his research work done at the Smithsonian Institution.

FOUNDING OF NCSM

CSIR was able to develop just two museums—BITM and VITM (Visvesvaraya Industrial & Technological Museum),

Upon graduation in Electrical and Control Engineering from Jadavpur University, Dr Ghose chose an unconventional path and joined BITM

Bangalore—during the period 1956 to 1978, besides planning for the Bombay museum. Noting the slow progress of museum projects under CSIR, on the recommendation of a taskforce and the decision of the Planning Commission, the Government of India decided to establish a separate organisation. This led to the formation of NCSM on 4 April 1978. Bose became the founder Director of NCSM. Post his retirement in 1979, Dr Ghose became the Director at this critical juncture.

The initial years of NCSM were fraught with challenges, including staff agitations and administrative hurdles. Yet, Dr Ghose's strategic foresight and ability to navigate turbulent times ensured NCSM's independence and growth. Dr Ghose had to plunge into the expansion mode while also addressing administrative problems that plagued NCSM. His ability to balance these challenges, while pushing for innovation, set the stage for NCSM's meteoric rise.

Dr Ghose's legacy is underscored by

the recognition of NCSM as one of the 100 Ideas that Transformed India, elucidated by veteran journalist Dinesh Sharma in his book, Indian Innovation, Not Jugaad: 100 Ideas That Transformed India. NCSM's inclusion reflects Dr Ghose's role in shaping India's scientific narrative.



All Images Courtesy: Wikimedia Commons

MOBILE SCIENCE EXHIBITION: SCIENCE ON WHEELS

Recognising that many students, especially in rural areas, could not visit the science museum in Calcutta, Dr Ghose decided to take museums to their doorstep. This bold initiative, born in an era of scarcity, embodied Dr Ghose's dream of a scientifically enlightened nation, making knowledge accessible to all, regardless of geography or means. His motto was "If you cannot come to the museum, the museum will come to you." The first MSE was launched on 17 November 1965, at Ramakrishna Mission School, Kolkata. Today, NCSM runs a fleet of over fifty MSE buses which traverse the length and breadth of the country.



Dr Saroj Ghose at an event in the presence of then Indian Prime Minister P V Narasimha Rao (at the back)

SCIENCE PARK

Dr Ghose introduced the science park, a concept that redefined informal science education. The Nehru Science Centre, Mumbai (NSCM), inaugurated in 1985, became the cradle for this innovation. Facing delays in the development of the museum, Dr Ghose decided to develop an open-air science park as the first phase of NSCM, a move that was both practical and visionary. Opened on 22 December 1979, the six-acre science park featured hands-on outdoor exhibits demonstrating principles of mechanics, optics, and more. The park houses vintage artefacts—steam and electric locomotives, a horse-drawn tram, an HAL HF-24 Marut fighter aircraft, century old electric Tata Electric Generator, among others—blending science with historical heritage.

UNESCO recognised this new concept as a unique informal science learning model and its success inspired science centres worldwide, particularly in the United States and Israel, to adopt similar models. Today, open-air science parks are a hallmark of NCSM centres.

SCALING THE SCIENCE MUSEUM MOVEMENT

From just two museums under CSIR—BITM, Kolkata and VITM, Bengaluru— NCSM under the leadership of Dr Ghose could develop 20 science centres, including national-level centres in Mumbai and Delhi, regional centres in Patna, Lucknow, Bhubaneshwar, Bhopal and Nagpur and district centres in Purulia, Tirunelveli and Gulbarga. Dr Ghose introduced a tiered model of science centres—national, regional, and district-level—to cater to diverse audiences. The establishment of the Central Research and Training Laboratory (CRTL) in Kolkata was a game-changer, fostering innovation in museum exhibits. Dr Ghose ensured NCSM embraced cutting-edge technologies. CRTL became a hub for developing state-of-the-art exhibits, positioning NCSM as a global leader in museum technology.

Dr Ghose's most ambitious project was the Science City, Kolkata, a sprawling complex that redefined the scale of science museums in India. Conceived as a self-sustaining entity, Science City attracts nearly 1.5 million visitors annually, a testament to Dr Ghose's foresight, and his ability to think big while ensuring practical implementation.

BRIDGING SCIENCE AND ART: THE KURUKSHETRA PANORAMA

Dr Ghose's ability to fuse science with art was exemplified in the Kurukshetra Panorama and Science Centre (KPSC), inspired by his visit to the Panorama Borodino in Moscow. The KPSC, opened in 2000 by then-Prime Minister Atal Bihari Vajpayee, features a massive 115-meter-long, 15-meter-high canvas depicting the epic Mahabharata battle. This project broke new ground by integrating art, history, and science, creating an immersive experience that attracts over 5,00,000 visitors annually. Dr Ghose envisaged a fusion of science and art into a single project, challenging the global silos between these disciplines. The KPSC remains a shining example of how museums can tell compelling stories through innovative mediums.

INTERNATIONAL INFLUENCE AND TECHNOLOGICAL INNOVATION

Dr Ghose's influence extended far beyond India. As president of ICOM from 1992 to 1998, he showcased India's prowess in museum innovation to the global community. He established the National Digital Laboratory (NDL) within NCSM, which produced high-quality ICOM publications at half the international cost. Unfortunately, this visionary project—which was ahead of its time—could not progress further with the retirement of Dr Ghose.

It was during Dr Ghose's time that a state-of-the-art Cyberskool, a multimedia computer lab facility, was established at NSC Delhi in 1996 with full financial funding and other technical support from Intel, USA. Incidentally, the author had the honour of leading this project. True to Cyberskool's envisaged impact of use of computer technology, multimedia and internet in education, the project became an instant success and soon, the second phase of Cyberskool facility was opened the very next year in NSC Delhi and thereafter in Mumbai. The monumentality of this project and its success, which ensured that Internet in its infancy in India reached the students, can be seen from the fact that the global CEO of Intel, Dr Craig Barret inaugurated both phase I and phase II of the Cyberskool projects. Ms Debjani Ghosh, who was until recently head of NASSCOM, was the project in charge of the Cyberskool as Intel representative.

Today, NCSM is the premier organisation in India, highly specialised in development of immersive and interactive technology for museums. This is borne out from the monumental research that takes place at CRTL, which has developed wide ranging technologies used across museums in India. Some of the projects developed by NCSM include the National Agriculture Science Museum, New Delhi, National Museum of Indian Cinema, Mumbai, among many others. The exhibition, 'Dinosaurs Alive', featuring 20 life size robotic dinosaurs, is another feat achieved by NCSM. This seemingly impossible project was realised due to extraordinary leadership of Dr Ghose.

During Dr Ghose's tenure at National Science Museum, New Delhi, a multimedia computer lab facility called Cyberskool was established in 1996

FESTIVAL OF INDIA

Conceived by Dr Ghose, the Festival of Science exhibition travelled across the US for two years (1985-87). This exhibition challenged stereotypes of India as a 'land of beggars and snake charmers' and highlighted its profound scientific and cultural heritage. The exhibition drew luminaries like Nobel laureate S Chandrasekhar, enduringly impacting global perception of India. This initiative not only elevated India's image abroad but also reinforced ancient India's extraordinary contributions in science.

POST RETIREMENT CONTRIBUTIONS

Dr Ghose created some of the best storytelling museums in the country post his retirement. These museums and projects include Kolkata Panorama for Kolkata Museum Society, Parliament Museum, Rashtrapati Bhavan Museum, etc. He was also the Museum Advisor to the President of India. He played a key role in the development of Gujarat Science City, Ahmedabad.

In recognition of his services to the museums, Dr Ghose was conferred with many national and international awards and recognitions including the Indira Gandhi Prize from the Indian National Science Academy, and the 'Hari Om Trust Award' for Popularisation of Science in 1988. In 2001, NCSTC awarded him the National Award for science popularisation. He received the Padma Shri in 1989 and Padma Bhushan in 2007. In 1996, Dr Ghose received the Primo Rovis International Prize from the Trieste International Foundation, Italy. The ASTC, an internationally acclaimed Association of Science and Technology Centers, USA, conferred on him its prestigious fellowship in 1997. He is the only Asian elected as the president of the International Council of Museums twice, during the period 1992-98.

Dr Saroj Ghose's contributions will continue to resonate in every science centre, every mobile exhibition, and every curious mind sparked by his vision. His visionary legacy lives on in NCSM and will continue to inspire curiosity in young minds. The author is humbled to be a Member of the NCSM Society, Ministry of Culture, Government of India.

**The writer is Senior Advisor, CSMVS Museum, Mumbai, and former director of NSC Delhi, NSC Mumbai and VITM Bengaluru.*

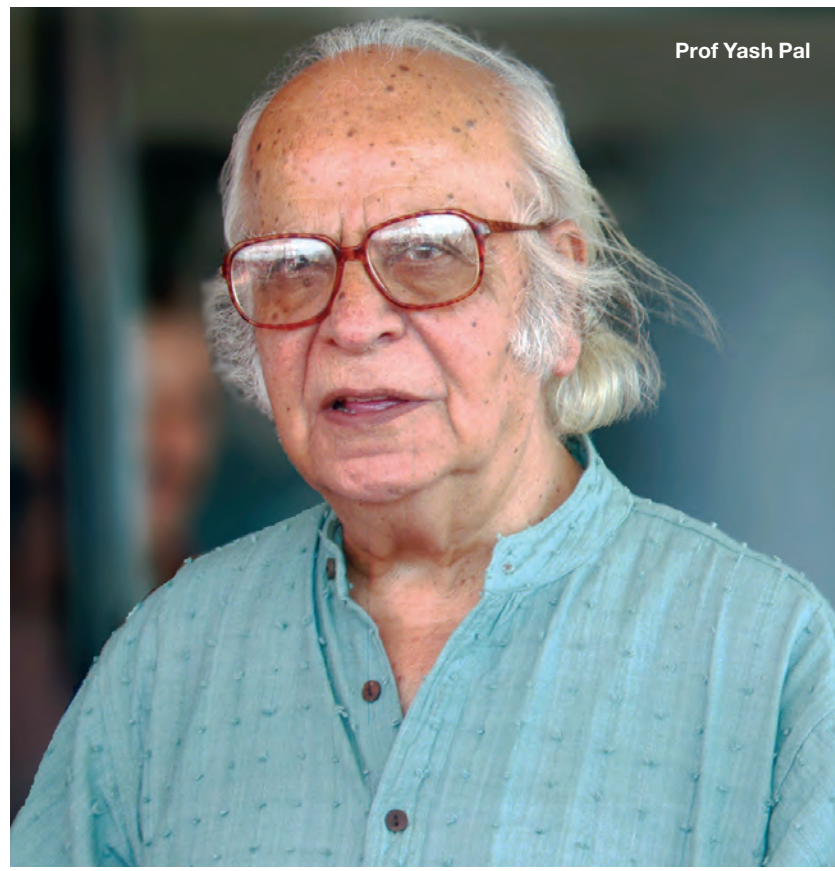
PROFILE OF THE MONTH: PROF YASH PAL (26 NOVEMBER 1926 – 24 JULY 2017)

The Scientist with a Vision

One of the most loved and recognised scientists of India, Prof Yash Pal's contributions in democratising science remain unparalleled



■ **Prof Jayanti Dutta**



Prof Yash Pal

Images Courtesy: Wikimedia Commons

Prof Yash Pal was one of those visionary Indian scientists who was able to deeply impact the world scientific scenario and also the public consciousness of the country. Having the good fortune of meeting him personally, I can vouch that his long, flowing snow-white tresses, ethnic *kurtas* and iconic straightforward communication devoid of any arrogance, endeared him to young and old alike, and Prof Yash Pal came through as a wise and '*rishi*' like personality. Prof Yash Pal's life of 90 years is also a chronicle of the development of science in this century in our country and how a 'life in science' was shaped by the forces of the times.

GROWING UP BETWEEN IDYLL AND CHAOS

Born on 26 November 1926, in Jhang, in the then undivided Punjab (now in Pakistan), Yash Pal's early life was marked by both idyllic moments and profound disruption. Due to his father's job in the education sector, the family settled in Quetta, a serene town nestled in the hills. The catastrophic 1935 Quetta earthquake killed over 60,000 people in the region while nine-year-old Yash Pal and his siblings were miraculously rescued from the rubble. The calamity, however, disrupted their schooling and left a lasting impression on his mind.

His formal education in science began at the Lahore campus of the University of the Punjab, where he pursued a BSc (Honours) in Physics during 1945–1947. A committed student activist, he participated in the Students Union at Lahore, engaging in spirited debates and championing the cause of education.

The Partition of India in 1947 once again disrupted Yash Pal's academic trajectory. Visiting Delhi at the time of the communal riots, he was unable to return to Lahore. Unperturbed by the turmoil, Yash Pal along with a group of other displaced teachers and students, created makeshift classrooms in World War II army barracks in Delhi, with the support of eminent physicist Prof D S Kothari. This makeshift institution evolved into the Delhi campus of Panjab University, where Yash Pal completed his MSc in Physics in 1949. After that, he moved to the United States to pursue a PhD at the Massachusetts Institute of Technology (MIT). In 1958, he was awarded his doctorate in Physics, focusing on cosmic rays—a field that would remain close to his heart throughout his scientific career.

Returning to India, Dr Yash Pal joined the Tata Institute of Fundamental Research (TIFR) in Bombay (now Mumbai), which had become a crucible of cutting-edge scientific research under the leadership of Homi J Bhabha. At TIFR, Dr Yash Pal immersed himself in the study of cosmic rays, contributing significantly to the understanding of these high-energy particles that bombard the Earth from space. His work earned him a reputation as a meticulous experimentalist and a creative thinker, laying

the groundwork for the vibrant community of Indian physicists studying cosmic rays and space science.

A SCIENTIST ADMINISTRATOR

One commonality seen in the career arcs of the scientists of those times is their contribution as impactful administrators. The nation was growing fast and in the early 1970s, as India embarked on an ambitious space programme, Prof Yash Pal's expertise was in high demand. In 1973, he was appointed the first Director of the newly established Space Applications Centre (SAC) in Ahmedabad,





Above: The then President, Pranab Mukherjee, presenting the Padma Vibhushan Award to Prof Yash Pal at the Investiture Ceremony at Rashtrapati Bhavan in New Delhi on 5 April 2013

Left: The then President Pratibha Devisingh Patil presenting the Lal Bahadur Shastri National Award 2011 for Excellence in Public Administration, Academics & Management to Prof Yash Pal in New Delhi on 15 October 2011

tasked with leveraging satellite technology for practical applications. At SAC, Prof Yash Pal championed the idea that space technology should serve the common man, advancing programmes in telecommunications, remote sensing and education. His leadership at SAC set the stage for India's pioneering use of space technology for national development.

His administrative talents shone brightly in a series of significant appointments. He was appointed Secretary General of the Second United Nations Conference on Peaceful Uses of Outer Space (1981–82), and later as Chief Consultant to India's Planning Commission (1983–84) and Secretary, Department of Science and Technology (1984–1986). Prof Yash Pal was to intervene creatively in yet another domain of higher education when in 1986, he became the Chairman of the University Grants Commission (UGC), the apex body for regulating higher education in India.

As UGC Chairman, Prof Yash Pal envisioned the creation of Inter-University Centres to foster collaborative research. This vision led to the establishment of the Inter-University Centre for Astronomy and Astrophysics (IUCAA) and other similar institutions that continue to thrive as hubs of interdisciplinary research. His tenure at UGC was marked by a focus on democratising higher education, enhancing research infrastructure, and promoting academic excellence across Indian universities.

Prof Yash Pal's tenure as UGC Chairman was marked by a focus on enhancing research infrastructure, among other things

BEYOND CLASSROOM

For Prof Yash Pal, science was not a dry subject to be mugged up through rote. Championing more hands-on and inquiry-based science education, he played a key role in the Hoshangabad Science Teaching Programme, in the early 1970s. This innovative programme aimed to replace rote learning with experiential understanding—a theme that would resonate throughout Prof Yash Pal's later work.

In 1993, the Ministry of Human Resource Development (MHRD) tasked Prof Yash Pal with leading a National Advisory Committee to examine the problem of overburdening school children. The committee's report, titled 'Learning without Burden', became a landmark document in Indian education. It argued forcefully for reducing the



Prof Yash Pal delivering the Foundation Day Lecture at the National Council for Teacher Education, New Delhi, on 17 August 2005

weight of school bags, making learning more meaningful and enjoyable, and reimagining the curriculum to foster creativity and critical thinking. This philosophy found further expression when Prof Yash Pal chaired the steering committee for the National Curriculum Framework (NCF) 2005, a transformative document that sought to make Indian school education more holistic and learner-centric. Under his leadership, the NCF embraced the idea of connecting knowledge to life outside the classroom and respecting the natural curiosity of children—a radical departure from the prevailing model of rote-based education.

Prof Yash Pal chaired the Committee on Higher Education in 2009 and his report, titled 'Renovation and Rejuvenation of Higher Education in India', called for sweeping structural changes to reinvigorate Indian universities, underscoring the need for greater academic freedom, institutional autonomy, and a renewed focus on research and innovation. This report became a blueprint for transformative change in India's higher education sector.

Prof Yash Pal was not just a scientist and an education reformer; he was also one of India's most beloved science communicators. His popular appearances on Doordarshan's *Turning Point*, a science television programme, brought complex scientific ideas to life for millions of viewers. With clarity, humour, and a gentle authority, he explained everything from the mysteries of the cosmos to the physics of everyday phenomena. His accessible style demystified science and inspired a new generation to embrace scientific thinking.

As a public intellectual, Prof Yash Pal was fearless in challenging superstition and pseudoscience. An avowed atheist, he dismissed astrology, religious rituals, and dogma as unscientific, advocating instead for a rational and evidence-based worldview. His columns in the English daily *The Tribune* answered readers' science-related questions with patient explanations and a rare combination of rigour and empathy.

Answering one of the questions of a reader who asked, 'We say the universe is expanding, but where is it expanding? I have also read about the contraction of space with time, can you give a description of that?' Prof Yash Pal's response was a reflection of his philosophy of science education. After answering the question, he advised, '… In general, do not seek answers to one line questions; instead seek to understand. One line answers might be good for quiz programmes but counterproductive for understanding and learning.' A profound advice, indeed.

Prof Yash Pal's many contributions were recognised with numerous awards and honours. In 1976, he was awarded the Padma Bhushan, one of India's highest civilian awards, for his work in science and space technology. In 2009, he received UNESCO's prestigious Kalinga Prize for popularising science. In 2011, he was honoured with the Lal Bahadur Shastri National Award for excellence in public administration, academics, and management. His crowning civilian honour came in 2013 when he was awarded the Padma Vibhushan, India's second highest civilian award.

Throughout his life, Prof Yash Pal remained a champion of scientific curiosity and social justice. He was unafraid to take on powerful interests, as demonstrated by his successful legal challenge in the Supreme Court against the proliferation of unregulated private universities in Chhattisgarh. In a landmark 2005 judgment, the court ordered the closure of 112 such universities, reaffirming the importance of academic standards and regulatory monitoring. Prof Yash Pal's tenure as Chancellor of Jawaharlal Nehru University (JNU) from 2007 to 2012 was a fitting culmination of his lifelong commitment to nurturing academic communities that value openness, dialogue, and critical inquiry.

He passed away on 24 July 2017, in Noida, Uttar Pradesh, at the age of 90. His death marked the end of an era, but his legacy endures in the institutions he helped build, the policies he shaped, and the countless minds he inspired. Prof Yash Pal's life is a testament to the power of science as a force for human progress. He showed that science is not just about equations and experiments—it is also about building communities, questioning received wisdom, and forging a better future for all. His tireless advocacy for education reform and science popularisation continues to resonate today, reminding us that curiosity, compassion, and courage can truly change the world.

**The writer teaches at Panjab University, Chandigarh.*

James Webb Takes Pictures of Exoplanet TWA 7b

James Webb Space Telescope, the largest human eye in space, captures direct images of its first exoplanet discovery

■ **Science India Bureau**

The James Webb Space Telescope (JWST) has captured its first unprecedented direct images of a planet beyond our own solar system, in its first exoplanet discovery.

The observations reveal a planet, which has been called TWA 7b, carving its way through a disc of glowing dust and rocky debris in orbit around a star 110 light years from the Earth.

Astronomers announced that Webb imaged a Saturn-mass planet orbiting the nearby young star TWA 7. Dubbed TWA 7 b, the planet's mass is only about 0.3 times that of Jupiter—roughly Saturn's mass—making it the smallest planet ever seen via direct imaging. Most of the nearly 6,000 known exoplanets have been detected indirectly. To spot TWA 7 b, the JWST team used a coronagraph (like a solar eclipse) to block the star's light and reveal the faint planet.

An attachment to Webb's MIRI instrument called a coronagraph masks the star, creating an effect similar to a solar eclipse. The telescope's infrared vision can then peer through and spot the planet.

Astronomers pointed Webb at the star TWA 7, which is around a hundred light years from Earth—relatively nearby in the universe.

According to the study published in the science journal, Nature, Webb's team targeted TWA 7 because its dusty disk is viewed nearly face-on, revealing clear ring structures. They used Webb's MIRI instrument with a coronagraph to mask the star's glare. After processing the data, a faint infrared point source appeared roughly 1.5 arcseconds from TWA 7 (about 50 times the Earth–Sun distance).

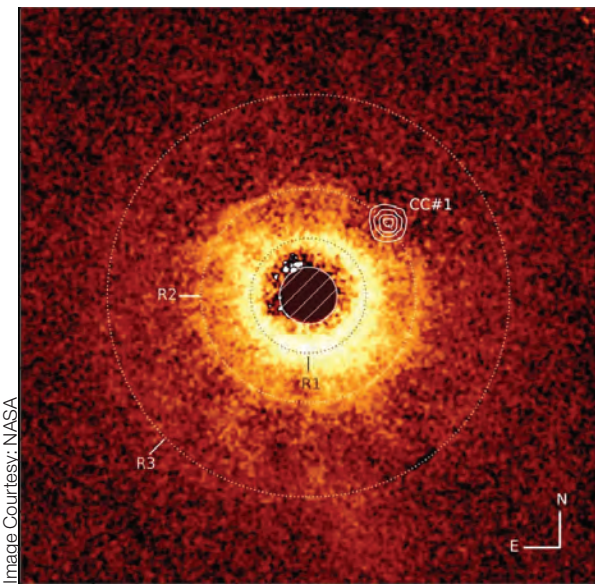


Image Courtesy: NASA

A picture of TWA 7b, the first exoplanet discovered by James Webb Space Telescope

This source lies in a gap of the star's second dust ring. Its brightness and colour match what theoretical models predict for a young, cold planet roughly the mass of Saturn. The object seems to be carving out the ring gap just as an orbiting planet would. Astronomers ruled out other explanations (like a background star) to confirm the signal is best explained by a planet.

Since the first exoplanet was discovered in 1992, nearly 6,000 more have been discovered, but almost all of these have been identified through indirect methods such as spotting the planet's shadow passing across the face of their host star.

The discovery of exoplanet TWA 7b, revealed in a study in the journal Nature, "represents a first for the telescope", France's CNRS research centre said in a statement.

The James Webb Space Telescope (JWST) is a space telescope designed to conduct infrared astronomy. As the largest telescope in space, it is equipped with high-resolution and high-sensitivity instruments, allowing it to view objects too old, distant, or faint for the Hubble Space Telescope.

This enables investigations across many fields of astronomy and cosmology, such as observation of the first stars and the formation of the first galaxies, and detailed atmospheric characterisation of potentially habitable exoplanets.

The telescope, which can see farther into the universe than anything before it, has turbocharged the search for planets beyond the Solar System since coming online in 2022.

Webb "has spent an enormous amount of time observing planets that have never been directly imaged," lead study author Anne-Marie Lagrange of the Paris Observatory said.

**Curated with reports from* Nature *and various published sources.*



NCPOR campus in Vasco-da-Gama, Goa

IN FOCUS: NATIONAL CENTRE FOR POLAR AND OCEAN RESEARCH, VASCO-DA-GAMA

Expanding the Horizon of Indian Polar Science

National Centre for Polar and Ocean Research in Goa is at the forefront of India's quest to decipher the role of cryospheric regions of the Earth

From the frozen expanse of Antarctica to the icy waters of the Arctic, and from the towering Himalaya to the depths of the Indian Ocean, the National Centre for Polar and Ocean Research (NCPOR) stands at the forefront of India's quest to understand and decipher role of cryospheric regions on our planet's climate system. This is the story of a national mission that has evolved into a global force in polar and oceanographic science, ensuring India's strategic and scientific presence in the world's most extreme and climate-sensitive regions.



■ **Dr Swati Nagar, Dr Avinash Kumar, Dr Rahul Mohan**

A JOURNEY FROM POLE TO POLE: THE GENESIS OF NCPOR

The story of the National Centre for Polar and Ocean Research (NCPOR) is as compelling as the frontiers it explores. Its journey began in 1994 as the Antarctic Study Centre, created to support India's nascent expeditions to the white continent. As India's scientific ambitions grew, the centre evolved, and was dedicated to the nation on 5 April 2000 as the National Centre for Antarctic and Ocean Research (NCAOR). With its mandate expanding beyond Antarctica to include the Arctic, and the Himalayas, it was aptly renamed as NCPOR in 2018. Today, as an autonomous institute under the Ministry of Earth Sciences (MoES), NCPOR is the nodal agency for India's polar programme, masterfully

managing scientific expeditions, fostering international collaborations, and conducting multidisciplinary research from its research base in Goa.

THE ANTARCTIC FRONTIER: A LEGACY OF SCIENCE AND PRESENCE

India's tryst with Antarctica began in 1981 with its first scientific expedition, codenamed 'Operation Gangotri'. In a remarkable feat of engineering and determination, the third expedition established India's first research base, Dakshin Gangotri, in a single austral summer of 1983–84. This paved the way for a continuous presence, now upheld by two year-round stations: Maitri (est. 1989), located in the Schirmacher Oasis, which supports research in geology, glaciology, and atmospheric sciences; and Bharati (est. 2012), a state-of-the-art facility in the Larsemann Hills, focusing on earth sciences and oceanography. Through 44 successful expeditions, India has enabled over 2,000 participants, including 85 women from more than 120 institutions, to conduct cutting-edge research on the continent. This work is conducted in strict adherence to the Antarctic Treaty System and the Indian Antarctic Act of 2022, ensuring that India's science is both impactful and environmentally responsible.

THE ARCTIC SENTINEL: TRACKING A RAPIDLY WARMING NORTH

With the Arctic warming three to four times faster than the rest of the planet, India recognised the urgent need for a scientific presence in the High North. In 2007, NCPOR launched the Indian Arctic Programme, establishing the Himadri research station in Ny-Ålesund, Svalbard (Norway), a year later. Research at Himadri targets climate change impacts, atmospheric sciences, and marine ecosystem dynamics. A major achievement of the programme was the 2014 deployment of IndARC, India's first multi-sensor ocean mooring system in Kongsfjorden, developed jointly by NCPOR, Goa and National Institute of Ocean Technology (NIOT), Chennai, to capture high-resolution data on Arctic warming. The Gruvebadet Atmospheric Observatory, established in 2015, tracks aerosols and precipitation, shedding light on long-range pollution transport and its impact on snow-ice interactions. India's Arctic ambitions have recently reached new milestones. In 2022, two NCPOR scientists reached the geographic North Pole, and in December 2023, India launched its first-ever winter expedition to Himadri, enabling advanced research on polar nights. The programme has also expanded geographically through a collaboration with the Canadian High Arctic Research Station (CHARS), with expeditions in 2023 and 2024 to study permafrost and microbial diversity.



Top: Bharati, the third Indian station in Antarctica, established in 2012; Above: Maitri, the second Indian station in Antarctica, established in 1988-89

THE SOUTHERN OCEAN: CHARTING THE GLOBAL CLIMATE ENGINE

The Southern Ocean surrounding Antarctica plays a central role in global ocean circulation, carbon cycling, and heat transport. India's first Indian Southern Ocean Expeditions (ISOE) were initiated in 2004 to understand the response of the Indian sector of the Southern Ocean to climate change. Utilising a multidisciplinary approach, the ISOE focuses on air-sea interaction, hydrodynamics, biological productivity, carbon cycling, and paleoclimate dynamics. So far, twelve ISOEs have been successfully launched, with contributions from numerous Indian institutions. The long-term studies in this area are crucial for understanding the influence of Southern Ocean ecosystem processes on both regional and global climate. The knowledge accrued through these expeditions has also led to India attaining a leadership role in international forums such as the Southern Ocean Observing System (SOOS).

THE HIMALAYAN CRYOSPHERE: TRACKING THE THIRD POLE'S ICE PULSE

NCPOR conducts extensive research in the Himalaya, where glaciers are highly sensitive indicators of climate change. Their retreat or advance directly impacts water availability across South Asia. Recognising the lack of long-term data, NCPOR launched a comprehensive glacier monitoring programme in 2013 in the Chandra Basin of Himachal Pradesh, studying six benchmark glaciers. To support this, NCPOR established Himansh, a high-altitude research station at 4,080 m above sea level in 2016. Recent studies show a connection between retreating Gepang glaciers

All Images Courtesy: NCPOR



The research vessel SA Agulhas was involved in an Indian expedition led by the NCPOR

and an increasing proglacial lake due to calving in the Chandra basin. Considering the benefits of collaboration, in 2018, NCPOR led the new initiative the Himalayan Cryospheric Observations and Modelling (HiCOM) project where collaborative projects in cryospheric observations and modelling on Himalayan glaciers implemented. Many national institutes such as IIT Roorkee, etc are implementing projects in collaboration with NCPOR.

In 2023–24, NCPOR expanded its glaciological studies to the Kameng Basin in Arunachal Pradesh. Through satellite data, fieldwork, and instrumentation, NCPOR is generating critical insights into glacier dynamics, climate impacts, and water resource forecasting.

DEEP OCEAN MYSTERIES: EXPLORING EARTH'S UNDERWATER FRONTIERS

Mapping India's Underwater Realm

Besides polar research, NCPOR undertakes strategically significant Deep Ocean programmes. India's Exclusive Economic Zone (EEZ) covers approximately 2.2 million km² along a 7,500 km coastline. NCPOR is the nodal agency designated to map the entire Indian EEZ using state-of-the-art technology. Partnering with NIOT, NIO, and GSI, over 90% of the EEZ mapping has been completed. A key milestone under this programme was the official naming of five undersea features discovered by the NCPOR team (including Chandragupta Ridge, Kalpataru Ridge and Ashok Seamount, Raja Raja Chola Seamount, and Harshvardhan Seamount) by the International Hydrographic Organization (IHO) and UNESCO-Intergovernmental Oceanographic Commission (IOC). The names are now published in the GEBCO Undersea Feature Names Gazetteer (https://ngdc.noaa.gov/gazetteer/).

Unlocking the Ocean's Riches: Hydrothermal Exploration

Hydrothermal vents along mid-ocean ridges are rich in metals like copper, zinc, gold, and silver. To explore these resources, the International Seabed Authority (ISA) allotted India a 10,000 km² area in the Central and South-West Indian Ocean in 2016. During a 2024 expedition, NCPOR scientists conducted India's first high-resolution exploration of these fields using the Autonomous Underwater Vehicle (AUV) Ocean Mineral Explorer–OMe 6000, developed by NIOT, at depths of 4,500 m. The mission identified several potential hydrothermal zones and polymetallic sulphide sites.

Decoding the Indian Ocean Geoid Low

The Indian Ocean Geoid Low (IOGL), the largest geoid anomaly on Earth, remains a scientific mystery. To explore its origin, NCPOR has conducted advanced seismological surveys, including the deployment of broadband Ocean Bottom Seismometers (OBSs). An array of 18 OBSs was deployed in 2024 and successfully retrieved in 2025. Data from previous expeditions revealed an



Members of the first winter Arctic expedition with then Union Minister of Earth Sciences Kiren Rijiju, and glimpses of their field activities at Gruvebadet

~800 km-wide depression at mantle transition zones, suggesting a hydrous mantle upwelling beneath the anomaly.

ADVANCED INFRASTRUCTURE & GLOBAL COLLABORATION

Technological Backbone of Research

NCPOR hosts advanced laboratories for cryospheric, geochemical, microbiological, and remote sensing research. It operates the research vessel Sagar Kanya and is building India's largest indigenously developed ocean research vessel under the Deep Ocean Mission and the Atmanirbhar Bharat initiative. NCPOR's ice-core lab, equipped with a Class 100 clean room, is one of its kind in India.

India's Role on the World Stage

NCPOR collaborates with international bodies like SCAR, IASC, and the Arctic Council, strengthening India's presence in global research. These partnerships enable joint expeditions, data sharing, and training. NCPOR has showcased India's leadership by hosting the 10th SCAR Open Science Conference (2022) and the prestigious 46th Antarctic Treaty Consultative Meeting (ATCM) in 2024. In 2024, it was the second time that India hosted ATCM, first was in 2007 in New Delhi.

Nurturing Future Generations

NCPOR is committed to building national capabilities in polar science through training programmes, fellowships, and academic collaborations. One of the benchmarks of its outreach is the biennial National Conference on Polar Science (NCPS), initiated in 2017 to bring together Indian polar scientists. The 4th edition is planned for September 2025.

Scientific Social Responsibility

In alignment with its commitment to Scientific Social Responsibility (SSR), the National Centre for Polar and Ocean Research (NCPOR) has undertaken a series of initiatives to promote public engagement and enhance awareness of the importance of polar and oceanic research. These initiatives, comprising a blend of online and offline activities, were designed to ignite curiosity about science and highlight the critical advancements in polar and marine domains. Over the past five years, NCPOR has facilitated over half a lakh interactions through outreach programmes, participation in national science fairs and exhibitions, and educational visits to its campus.

TIMELINE

1983: First Indian station in Antarctica—Dakshin Gangotri established

1988-89: Maitri, second Indian station in Antarctica established

2007: India's first Arctic expedition launched

2008: Himadri, Indian station in Svalbard, at the convergence of Arctic and Atlantic oceans, established

2010-2011: First Indian expedition to the South Pole

2012: Bharati, third Indian station in Antarctica established

2016: Himansh, India's Remote, High-Altitude Station in Chandra basin, inaugurated

2021: DOM launched by MoES. NCPOR entrusted with deep ocean survey and exploration

2022: NCPOR scientists reach the North Pole for the first time, as part of the Central Arctic expedition.

2022: Indian Antarctic Act and Arctic Policy Released

THE ROAD AHEAD: FUTURE DIRECTIONS

NCPOR is poised to take on greater challenges in the coming years. Key priorities include strengthening, modelling and forecasting of polar-ocean-climate interactions and building India's capacity in polar logistics, including the ownership of an icebreaker vessel. NCPOR stands as a beacon of India's scientific prowess, and through its sustained efforts, not only contributes to national goals but also plays a vital role in the global quest to understand Earth's climate, oceans, and life-support systems.

**Dr Swati Nagar is Project Scientist II, Outreach and Cooperation Section in National Centre for Polar and Ocean Research, Goa, where Dr Avinash Kumar is Scientist E and Scientist-In-Charge, Outreach and Cooperation Section, and Dr Rahul Mohan is Scientist G and Group Director.*



HERB HERITAGE: CORIANDER

The Cooling Herb of Ayurveda

Coriander is proof that often, the most effective cures are those that have always been in our kitchens

Coriander, also known as Dhaniya or Dhanyaka in Ayurveda, has been a popular culinary and medicinal herb for thousands of years throughout cultures. Ayurveda describes coriander as a potent *shita virya* (cooling potency) herb with *madhura* (sweet) and *katu* (pungent) rasa, as well as *laghu* (light) and *snigdha* (unctuous) *guna*. Modern kitchens use its aromatic leaves and seeds. It calms the Pitta and Kapha *dosha*s and provides a wide range of therapeutic advantages, including digestion, detoxification, hormonal balance, and skin health.

In Ayurveda, the fruits are employed as astringent, aromatic, anthelmintic, emollient, anti-inflammatory, stomachic, carminative, antibilious, digestive, appetizer, constipating, diuretic, antipyretic, stimulant, aphrodisiac, refrigerant, tonic, expectorant, anodyne, dyspepsia, and so on.



■ Vaidya Preeti Bhosle

Coriander is a simple yet extremely useful herb in the Ayurvedic pharmacopeia. Its soothing, cooling, and balancing characteristics make it an essential tool for addressing Pitta-related disorders in digestion, skin, hormones, or emotions. With an increasing global interest in functional foods and herbal treatments, coriander finds itself at the crossroads of tradition and science, demonstrating that often the most effective cures are those that have always been in our kitchen.

Ayurvedic Pharmacological Perspective

Rasa, Guna, Virya, Vipaka

- **Rasa (taste):** Madhura (sweet), Tikta (bitter), Kashaya (astringent)
- **Guna (qualities):** Laghu (light), Snigdha (slightly unctuous)
- **Virya (potency):** Shita (cooling)
- **Vipaka (post-digestive effect):** Madhura (sweet)
- **Doshic Action:** Pacifies Pitta and Kapha, mildly aggravates Vata in excess

Ayurvedic Formulations and Use Cases

1.Dhanyaka Siddha Jala: Coriander seed-infused water for digestive and urinary health.

2. Trikatu Yogas: Though not typically part of classical Trikatu, coriander is sometimes used adjunctively to temper the heating effects of Pippali and Ginger.

3. Sheetpitta (Urticaria), Amlapitta (Hyperacidity): As a coolant and anti-inflammatory agent.

4. Krimi (Parasites), Jwara (Fever): Used in decoctions with cumin and fennel.

Medicinal Uses

1. Digestive Health

Coriander's most well-known benefit lies in improving agni (digestive fire) without aggravating Pitta. It enhances appetite, relieves flatulence, reduces bloating, and combats nausea. In contemporary medicine, coriander is considered a carminative and digestive stimulant, often used in formulations for irritable bowel syndrome (IBS).

Tip: Soaked coriander seeds boiled in water make an excellent digestive tea post meals.

2. Urinary Tract and Renal Health

Coriander is an effective mutrala (diuretic) and mutrakrichra hara (alleviates painful urination). In cases of UTI, burning micturition, and early-stage renal inflammation, coriander seed decoction is a safe and natural adjunct.

Studies confirm coriander's diuretic

Image Courtesy: Wikimedia Commons

and anti-urolithiatic (anti-kidney stone) properties, attributed to its flavonoids and phenolic acids.

The aqueous coriander extracts, used at concentrations of 0.04 and 0.10 g per kilogram used in arterial distillation, enhanced diuresis and urine flow of sodium, potassium, chloride, and glomerular filtration rate. The diuretic impact of coriander appeared to be similar to that of furosemide.

3. Skin Disorders and Pitta Imbalance
In conditions like *sheetapitta* (urticaria), *pama* (eczema), or *vidradhi* (boils), coriander acts as a cooling, detoxifying agent. External pastes or internal decoctions help purify blood (*rakta shodhana*) and calm inflammatory responses.

Modern research notes coriander's anti-histamine and anti-inflammatory actions, useful in allergic skin conditions and dermatitis.

5. Blood Sugar Regulation
In Ayurveda, coriander is not traditionally used as a primary anti-diabetic herb, but it is supportive due to its Pitta-pacifying and digestive-enhancing effects. Recent studies show that coriander seed extracts improve insulin secretion, reduce blood glucose levels, and enhance liver antioxidant defences.

It is especially useful in pre-diabetic states or Pitta-dominant metabolic dysfunctions.

6. Antiaging Activity
For limited applications, long-chain fatty acids may be useful in anti-aging products. Consequently, the long-chain fatty acids can be quantified as latent anti-aging symbols. Fruit oils are very ironic when it comes to these kinds of fatty acids. Current studies using coriander fruit oil as a remedy for various skin conditions and as an ingredient in herbal sunscreens seem highly promising.

7. Anxiety, Insomnia, and Nervous Disorders
The cooling and calming properties of coriander make it a *manas dosha* pacifier, especially beneficial in Pitta-type emotional imbalance—marked by anger, irritability, or insomnia.

Linalool, a major component of its essential oil, has shown anxiolytic and mild sedative effects in pharmacological studies. Coriander tea can be a gentle nervine tonic in psychosomatic disorders.

8. Anti-anxiety actions
The aqueous decoction of coriander has an antianxiety action and own opiate and muscles tranquilizer properties.

9. Cardioprotective Activity
It has been found that the hydromethanolic extract of coriander fruits has cardio-protective properties. This outcome is supposed to result from the fruit's highest levels of polyphenols.

10. Antinuclear action
In order to protect the human body from the harmful effects of heavy metals and other dietary toxic elements, coriander has been an essential herb since ancient times. It has also proven its mettle to be an important drug in preventing Helicobacter pylori from causing stomach ulcers. This plant's anti-gastric ulcer and antisecretory mode of action has also been determined through rigorous scientific analysis, and it is readily involved in scavenging reactive oxygen species on the surface of the gastric mucosa. It is also believed to form a protective coating through hydrophobic exchanges, which may accompany the antioxidant qualities of various elements present in this plant.

11. Women's Health and Hormonal Balance
Coriander, while not a traditional *stanya janana* (galactagogue), indirectly promotes lactation by aiding digestion and cooling excessive Pitta after delivery. It also helps with menstruation abnormalities, particularly those caused by Pitta aggravation such as acne, irritation, heavy flow, or hot flushes.

Its phytoestrogenic potential is being investigated in modern endocrinology.

Culinary and Functional Applications

- Raw coriander leaves are rich in chlorophyll, aid digestion, and are often used in *chutney*s and salads.
- Coriander seed powder can be added to buttermilk (*takra*) for a gut-soothing, probiotic-rich drink.
- Coriander-infused water is traditionally consumed in summers to prevent heatstroke and dehydration.

Plant parts used: Whole Plant

Fruit: Aromatic, astringent, emollient, anti-inflammatory, anthelmintic, stomachic, carminative, antibilious, digestive, appetizer, constipating, diuretic, antipyretic, stimulant, aphrodisiac, refrigerant, tonic, expectorant, anodyne, useful in burning sensation, cough, bronchitis, sore throat, common catarrh, vomiting, dyspepsia, anorexia, colic, flatulence, diarrhoea, dysentery, chronic conjunctivitis, headache, epitasis, erysipelas, strangury, dropsy, chronic ulcers, carbuncles, scrofula, helminthiasis, haemorrhoids, intermittent fever, hyper dyspepsia, gout, rheumatism and giddiness.
Seed oil: Flatulent colic, rheumatism, neuralgia.
Leaves: Aromatic, astringent, analgesic, carminative, antibilious, anti-inflammatory, styptic, useful in halitosis, throat disorder, epistaxis, bleeding from gums, chronic conjunctivitis, erythema, hiccough, inflammation, suppuration, haemorrhoids, jaundice and odontalgia.

Dosage and Cautions

- Powder: 3–6 grams per day
- Infusion/Tea: 10–15 coriander seeds soaked overnight and boiled in 1 cup water
- Essential oil (external use only): Dilute in carrier oil for massage or aromatherapy

Contraindications

- Excessive use may aggravate Vata (due to its drying nature).
- Should be used cautiously in people with low digestive fire (*manda agni*).
- Essential oil should not be ingested.

**The writer is an Ayurveda physician, DST Woman Scientist A, AIIMS New Delhi, and founder of Pratha Ayurveda.*

YOUNG SCIENTIST/ DR PRAGYA YADAV

India's Frontline Virologist and Vigyan Yuva Puraskar Laureate

Dr Pragya Yadav's research significantly advances India's preparedness for disease outbreaks and vaccine development

■ **Science India Bureau**

In the world of modern science, where silent threats like viruses can bring the world to a standstill, the role of virologists becomes not only essential but heroic. Among India's leading figures in this field is Dr Pragya Dhruv Yadav, a distinguished scientist at the Indian Council of Medical Research—National Institute of Virology (ICMR-NIV), Pune. In 2024, she was conferred the prestigious Vigyan Yuva - Shanti Swarup Bhatnagar Award under the Rashtriya Vigyan Puraskar framework for her outstanding contributions to the field of medical sciences, particularly virology and infectious diseases.

Born on 1 July 1978, in Sant Kabir Nagar, Uttar Pradesh, Dr Yadav has emerged as one of India's foremost experts on high-risk viral pathogens. She leads India's only BSL-4 (Biosafety Level-4) laboratory, a high-containment facility equipped to study the world's most dangerous viruses—those for which neither vaccines nor effective treatments exist. From Ebola and Nipah to Crimean–Congo Hemorrhagic Fever (CCHF), Kyasanur Forest Disease, and mpox, Dr Yadav has been at the forefront of identifying, diagnosing, and containing deadly disease outbreaks across the country.

Her momentous role came into national and global prominence during the COVID-19 pandemic. Under her leadership, the NIV team successfully isolated India's first SARS-CoV-2 strain in early 2020—critical for both the understanding of the virus and the development of diagnostic kits and vaccines. This paved the way for pre-clinical studies that eventually led to India's first indigenous vaccines: Covaxin by Bharat Biotech and ZyCoV-D by Zydus Cadila. Her work not only shaped India's response to COVID-19 but also ensured that the country was not solely dependent on foreign research for crucial biomedical interventions.



Image Courtesy: PIB

Dr Pragya Yadav receiving the Vigyan Yuva Shanti Swarup Bhatnagar award from the President of India Droupadi Murmu

Yet, Dr Yadav's scientific contributions extend far beyond COVID-19. Over the years, she has authored more than 225 peer-reviewed research papers on various viral threats. She has contributed significantly to India's understanding of diseases like Zika, Avian Influenza (H5N1), Chandipura virus, West Nile virus, and Hantaviruses. Through her work in active surveillance, laboratory diagnosis, and pathogen characterisation, she has helped India build a strong foundation for epidemic preparedness and biosafety governance.

She has also served as Principal Investigator for several national and international research collaborations and is frequently consulted by central and state health departments during outbreak investigations. Her work with the World Health Organization (WHO) on high-risk pathogens further illustrates her global engagement in managing zoonotic and emerging diseases.

The significance of Dr Yadav's work lies not just in science, but in the policy and practice it influences. By operating at the interface of laboratory science and public health administration, she ensures that her research translates into real-time interventions on the ground. Whether it is deploying mobile labs to test for viral hemorrhagic fevers in rural belts or training young scientists in biosafety protocols, she has been instrumental in creating a scientific ecosystem that is resilient, responsive, and deeply rooted in public service.

In addition to this honour, Dr Yadav has been elected as a fellow to several prestigious scientific bodies, including the National Academy of Agricultural Sciences (NAAS), the Indian Virological Society (IVS), and the National Academy of Medical Sciences (NAMS). Her career is a shining example of how excellence in research, when combined with a vision for public good, can fortify a nation's scientific stature.

A Green Step Forward in Smarter Urban Navigation

An IIT Kharagpur team develops possibly the world's first urban mobility app that factors in environmental and health concerns in route selection

■ **Science India Bureau**

In the face of increasing air pollution and urban congestion, India has taken a significant step towards sustainable urban mobility with the launch of the DRUM app—Dynamic Route Planning for Urban Green Mobility. Developed by a team at the Indian Institute of Technology (IIT) Kharagpur, this innovative web application introduces an eco-conscious alternative to traditional navigation systems by integrating real-time traffic updates with live pollution data, thereby helping users choose not just the fastest route, but the healthiest and the most energy-efficient one as well.

Unlike standard apps that focus on distance and time alone, DRUM offers five route choices to suit different user priorities: the shortest route, the fastest route, the LEAP (Least Exposure to Air Pollution) route, the LECR (Least Energy Consumption Route), and a suggested route that balances all four factors.

This nuanced route selection makes DRUM the first of its kind in India, possibly even globally, to weave environmental and health concerns directly into daily commuting decisions.

At the heart of the app's operation is a combination of powerful tools and data networks. DRUM uses GraphHopper, a Java-based routing engine, to generate multiple possible routes between two points. It pulls real-time traffic data from Mapbox and pollution metrics from the Central Pollution Control Board (CPCB) and the World Air Quality Index.

Since many Indian cities lack dense air-quality sensor networks, DRUM employs a technique called spatial interpolation—essentially predicting pollution levels in areas between sensors by calculating estimates based on nearby readings. This ensures the app remains functional and informative even in areas with limited monitoring.

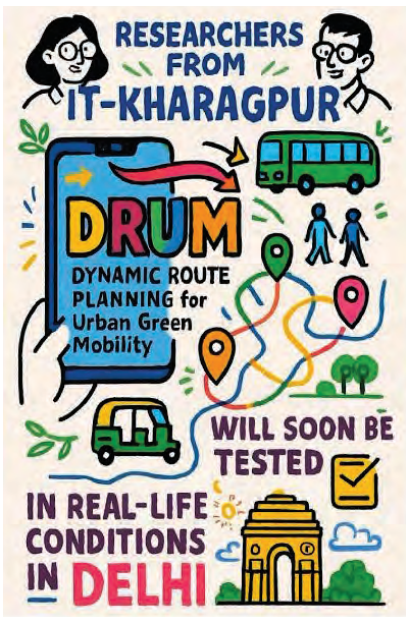


Image Courtesy: Twitter

In trials conducted across various corridors in Delhi, DRUM demonstrated its practical value. For instance, in the central parts of the capital, LEAP routes helped reduce exposure to pollutants by up to 50 percent, albeit with a 40 percent increase in travel time. Similarly, in South Delhi, LECR routes cut estimated energy consumption by as much as 28 percent. These findings indicate that although eco-friendly routes may require longer travel times, they offer tangible benefits in terms of health and fuel savings—benefits that are likely to outweigh the delays in the long run.

The significance of DRUM is far-reaching. It aligns well with India's broader sustainable development goals, particularly SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). Beyond its environmental advantages, the app has potential public health implications by reducing long-term exposure to vehicular pollutants—factors linked to rising rates of asthma, lung disease, and heart conditions in urban populations.

By empowering users to choose less polluted routes, DRUM addresses urban health concerns in a proactive manner.

The app also fits into the larger vision of smart governance and data-driven policy. It exemplifies how digital solutions can serve as tools of empowerment, encouraging behavioral change without mandates. Cyclists, pedestrians, and public transport users, often the most affected by traffic-related pollution, stand to benefit immensely from such targeted route suggestions.

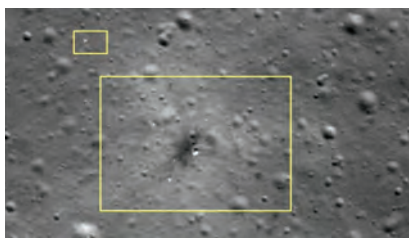
Despite its promise, DRUM is not without challenges. One of the primary limitations is the sparse network of air-quality monitoring stations across many Indian cities, which could affect the accuracy of pollution mapping. Additionally, user adoption will be a crucial factor in determining its long-term success. Competing with well-established apps like Google Maps requires both public awareness and institutional support. However, the developers plan to integrate predictive analytics and machine learning features in future versions, allowing for even smarter route suggestions based on anticipated traffic and pollution patterns. There are also plans for a DRUM 2.0 version, which will include real-world pilot testing in Delhi, providing a valuable opportunity to refine the app based on user feedback and behavioral studies.

As India navigates the challenges of rapid urbanisation and climate change, the DRUM app offers a compelling vision for the future of mobility—one where speed and convenience do not come at the cost of health and sustainability.

By making every commute a conscious choice, DRUM enables citizens to play an active role in creating cleaner, greener cities. If supported with the right policy backing and public participation, it could well redefine how India moves and breathes.

Chandrayaan-2 helps locate debris of crashed Japanese moon lander

In a remarkable instance of global collaboration and citizen science, India's Chandrayaan-2 mission has helped identify the debris of Japan's crashed lunar lander, Hakuto-R2.



Shanmuga Subramanian used hi-res images from Chandrayaan-2 to locate the debris of Japanese moon lander

Space enthusiast Shanmuga Subramanian, known for previously spotting the remains of India's Vikram lander, used high resolution images from Chandrayaan-2's Orbiter High Resolution Camera (OHRC) to pinpoint the scattered wreckage.

The Japanese lander lost contact during its descent while attempting to land in the Moon's northern hemisphere, in the region known as the Sea of Cold earlier in the month of June. Mission Control in Tokyo was unable to re-establish telemetry, sparking a global search for the spacecraft's fate.

ISRO transfers SSLV technology to HAL

In a major milestone for India's commercial space ecosystem, the Indian National Space Promotion and Authorization Centre (IN-SPACe) has officially transferred ISRO's Small Satellite Launch Vehicle (SSLV) technology to Hindustan Aeronautics Limited (HAL). HAL will now handle the manufacturing, marketing, and launching of SSLV for commercial small satellite missions. A formal agreement involving ISRO, HAL, NewSpace India Limited (NSIL), and IN-SPACe is set to be signed to initiate the transfer process.

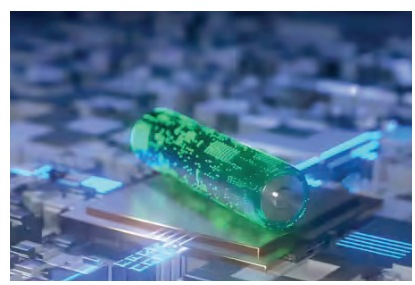
Designed for on-demand, low-cost launches of satellites up to 500 kg into low Earth orbit, the SSLV promises to boost India's competitiveness in the fast-growing global small satellite market.

GalaxEye's second satellite for earth observation

Bengaluru-based space-tech startup GalaxEye has announced its second satellite, designed to offer near 0.5-meter resolution imaging. The move marks a significant step forward for India's private satellite capabilities. The satellite, building on the company's SAR-optical fusion technology, aims to provide precise, rapid geospatial intelligence for sectors such as defence, disaster management, and urban planning. The announcement comes ahead of the launch of GalaxEye's debut mission, Drishti, scheduled for later this year.

Indian scientists develop safer lithium-ion battery technology

In a significant advancement for battery safety, researchers at Shiv Nadar Institution of Eminence have developed a thermoresponsive electrolyte that actively mitigates the risk of catastrophic lithium-ion battery failures. Published in *Advanced Functional Materials*, the research introduces a



Scientists may have found a solution for thermal runaway issues of lithium-ion batteries

material that responds to excessive heat more reliably than conventional polymer separators, which often fail beyond 160°C. This innovation could have major implications for the safety of lithium-ion-powered devices like smartphones, electric vehicles, and laptops, where the risk of thermal runaway remains a key challenge.

India overtakes Pakistan in nuclear warhead stockpile

India now has a larger nuclear arsenal than Pakistan, according to the 2025 yearbook of the Stockholm International Peace Research Institute (SIPRI). The report states that India's stockpile has grown from 172 nuclear warheads in 2024 to 180 in 2025, while Pakistan's remains unchanged at



A thinktank report suggests India has increased its nuclear warheads

170. Warheads of both the countries are part of active stockpiles, meaning they are available for deployment if needed. The report highlights India's gradual increase in strategic capabilities amidst regional security dynamics.

Indian astronomers discover unusual stellar chemistry in distant star

Astronomers from the Indian Institute of Astrophysics (IIA), Bengaluru, have discovered a rare star with unexpected chemical properties, challenging existing theories of stellar composition. Located in the Ophiuchus constellation, about 25,800 light-years away, the star—named A980—was found to contain unusually high amounts of germanium, a metallic element not previously detected in its class. Initially misidentified as a hydrogen-deficient carbon star, A980's spectral fingerprint instead resembled that of LS IV –14° 109, a rare "Extreme Helium" (EHe) star. EHe stars are exceptionally rare and believed to form from the merger of two white dwarfs—one carbon-oxygen rich, the other helium-rich. This discovery, made using the Himalayan Chandra Telescope in Ladakh, offers new insights into the life cycles of stars and the chemical diversity of the cosmos.

All images courtesy: Internet

Are Indonesia's frequent volcanic eruptions linked to global warming?

The eruption of Mount Lewotobi Laki in Indonesia on June 18 has drawn global attention with its massive ash plume rising up to 11 kilometers into the atmosphere. The ash was visible from cities more than 150 kilometers away, significantly disrupting air travel across the region. Over 37 international and domestic flights to and from Bali's I Gusti Ngurah Rai International

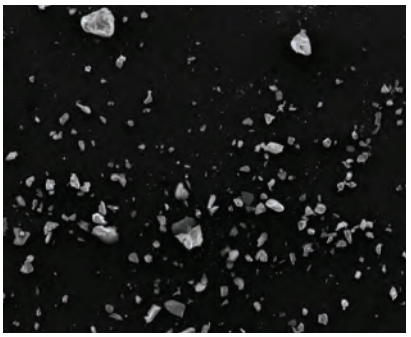


Recent eruption of Mount Lewotobi Laki threw massive ash plumes up to 11 kilometres in the atmosphere

Airport were cancelled. Flights operated by Air India, Singapore Airlines, Jetstar, Air New Zealand, Juneyao Airlines, and Virgin Australia were among those affected. The Fransiskus Xaverius Seda Airport in Maumere has been shut indefinitely due to ashfall risks. Authorities are particularly concerned as the eruption occurred during the monsoon season, raising the risk of lahars—dangerous volcanic mudflows that form when heavy rain mixes with volcanic ash.

Moon dust is less harmful to human lungs than city pollution

A new study by the University of Technology, Sydney (UTS), has revealed that lunar dust is significantly less harmful to human lung cells than previously assumed. The research found it to be far less toxic than typical Earth-based air pollutants. The findings arrive as nations like the US, China, and Russia gear up for manned missions to the Moon, with long-term plans for colonisation. The data brings encouraging news for upcoming missions



Moon dust particles are less toxic than air pollutants on Earth

such as NASA's Artemis programme, aimed at establishing a sustained human presence on the lunar surface.

Europe's Proba-3, launched from India, creates first artificial solar eclipse

The European Space Agency's Proba-3 spacecraft, launched from Sriharikota, India, on 28 March 2025, has successfully created the first artificial solar eclipse in space. Flying in perfect formation, the Proba-3 satellites blocked out the Sun's bright disc to reveal the Sun's mysterious outer atmosphere—the corona—which burns millions of degrees hotter than the solar surface and drives disruptive solar storms.

First-of-its-kind brain-computer helps man with ALS speak in real time

In a remarkable advancement in medical science, researchers from the University of California, Davis, have developed a brain-computer interface that allows real-time speech for patients who have lost the ability to talk. The device was successfully demonstrated with an ALS patient, whose brain activity was translated into speech as he communicated with his family. The system even replicated the patient's intonation and enabled him to 'sing' simple tunes. Published on 17 June 2025, in the journal Nature, the study outlines the device's ability to simulate a full artificial vocal tract.

Europe's Solar Orbiter captures first images of Sun's poles

The European Space Agency (ESA), on June 18, released the first-ever images of the Sun's poles captured by the Solar Orbiter spacecraft. Taken in March 2025, the images show the Sun's south pole from a distance of about 65 million kilometers. Images of the north pole are still being transmitted. The Solar Orbiter, a joint mission by ESA and NASA, was launched in 2020 to deepen understanding of solar magnetic fields, solar winds, and the Sun's 11-year activity cycle.

NASA building a JCB to excavate Moon rocks

NASA is currently testing a lunar digging machine known as the Regolith Advanced Surface Systems Operations Robot (RASSOR), designed to excavate Moon rocks and soil using large



RASSOR is being designed to excavate moon rocks and soil

counterrotating bucket drums. In tests conducted in early June 2025 at the Granular Mechanics and Regolith Operations Lab at Kennedy Space Centre in Florida, RASSOR successfully dug into simulated lunar dust and built a three-foot berm. NASA plans to use this system aboard IPEx, its upcoming Moon-mining robot, to demonstrate advanced autonomous excavation technology crucial for lunar resource utilisation.

All images courtesy: Internet

Quiz

1. ICAR-CCRI (Indian Council of Agricultural Research-Central Citrus Research Institute) and Visvesvaraya National Institute of Technology are collaborating to create biodegradable packaging using:
A. Coconut husk fibres
B. Sweet orange peel waste
C. Sugarcane bagasse
D. None of the above

2. The Raja Ramanna Centre for Advanced Technology in Indore recently hosted a meeting on laser tech for nuclear applications focusing on:
A. Laser fusion energy
B. Additive manufacturing and non-destructive testing
C. Medical laser surgery
D. None of the above

3. Scientists at Raiganj University discovered a new soil bacterium named:
A. Bacillus ayatagriensis
B. Pseudomonas sericicola
C. Streptomyces mulberronis
D. None of the above

4. The Andhra Pradesh MedTech Zone (AMTZ) in Vizag is notable for its work in:
A. Cancer vaccine development
B. Pacemaker lead production & e-waste recycling
C. Space medicine
D. None of the above

5. IIT-Madras Zanzibar launched a new UG degree in:
A. Aerospace Engineering
B. Chemical Process Engineering
C. Environmental Science
D. None of the above

6. UP Board's new science teaching approach emphasises:
A. Online video lectures
B. Hands-on experiments and interactive modules
C. Competitive exam drills
D. None of the above

7. ISRO is funding carbon farming at Rajendra Prasad Central Agricultural University, installing which key instrument?
A. LIDAR atmospheric profiler
B. Eddy covariance tower
C. Soil moisture satellite
D. None of the above

8. India is using AI and satellites in 2025 to tackle:
A. Crop pest outbreaks
B. Urban heat-vulnerability mapping down to buildings
C. Coastal erosion
D. None of the above

9. A major new underwater sensor network in the Indian Ocean is intended for:
A. Marine biodiversity surveys
B. Tsunami & earthquake early warning
C. Submarine detection
D. None of the above

10. Scientists from Bihar Agricultural University (BAU) introduced new varieties of rice including flood-tolerant Sabour Shri Sub-1, designed for:
A. High-altitude regions
B. Climate resilience—flood, disease, yield
C. Desert agriculture
D. None of the above



A 24-million-year-old secret

■ In Northeast India's ancient coal beds (Makum Coalfield, Assam), scientists have discovered fossil leaves resembling the modern Nothopegia genus.

■ These fossils, dating to about 24–23 million years ago (late Oligocene epoch), are the oldest known fossil record of Nothopegia in the world.

■ Today, Nothopegia grows only in the Western Ghats, which is a UNESCO World Heritage Site and a key biodiversity hotspot.

■ Using palaeobotany, systematics, herbarium comparison, cluster analysis, and climate modelling, scientists determined that the Northeast once had a warm, humid climate similar to Western Ghats today.

■ Tectonic shifts, including the rise of the Himalayas, dramatically altered climate in the northeast—making them cooler and less suitable for tropical plants like Nothopegia, leading to its disappearance from the region.

■ The species survived in the Western Ghats, a climatically stable refuge, making it a living relic of an ancient ecological landscape.

■ This discovery shows that climate change is an ancient, natural process—but unlike the past, modern climate change is occurring much faster due to human activities.

■ The discovery helps predict how plants might respond to global warming and highlights the need to protect biodiversity refuges like the Western Ghats.

Answers : 1 (B); 2 (B); 3 (C); 4 (B); 5 (B); 6 (B); 7 (B); 8 (B); 9 (B); 10 (B)

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Indian astronaut at International Space Station



Image Courtesy: NASA

The Axiom Mission 4 (Ax-4) and Expedition 73 crews join each other for a group portrait inside the International Space Station's Harmony module. In the front row (from left) are, Ax-4 crewmates Tibor Kapu, Peggy Whitson, Shubhanshu Shukla, and Sławosz Uznanski-Wisniewski with Expedition 73 crewmates Anne McClain and Takuya Onishi. In the rear are the other Expedition 73 crewmates: (from left) Alexey Zubritskiy, Kirill Peskov, Sergey Ryzhikov, Jonny Kim, and Nichole Ayers.

July
2025

Celebrating Science This Month

JULY 1
IRNSS-1A, the first satellite in the Indian Regional Navigation Satellite System, was launched in 2013 by PSLV - C22 from SDSC-SHAR Centre, Sriharikota.

National Doctors' Day.

JULY 2
World UFO Day.

Mizoram University was established in 2001.

JULY 4
Swami Vivekananda, the great scientific visionary, passed away in 1902.

JULY 6
World Zoonoses Day.

Daulat Singh Kothari was born in 1906. He was elected as the General President of the Indian Science Congress in 1963 and President of the Indian National Science Academy in 1973. His research on Statistical Thermodynamics and Theory of White Dwarf Stars gave him global recognition.

JULY 10
INSAT-2A was launched in 1992 by Ariane 4, whereas INSAT-4C was launched from SHAR, Sriharikota in 2006.

Indian American scientist Ananda Chakrabarty, who patented the first genetically engineered life form, passed away in 2020.

JULY 11
World Population Day.

Cotton scientist Chandrakant T Patel was born in 1917. He developed the first commercial cotton hybrid, known as Hybrid-4 (Sankar-4), in 1970.

JULY 12
CARTOSAT-2B was launched in 2010 by PSLV-C15 from SHAR Centre Sriharikota.

JULY 14
T S Chandrasekar, Padma Shri awardee, globally renowned Interventional Gastroenterologist and the founder and chairman of MedIndia Hospitals, Chennai, was born in 1956.

JULY 15
GSAT-12 was launched in 2011 by PSLV-C17 from SHAR, Sriharikota.

World Youth Skills Day.

JULY 16
Indian Council of Agricultural Research (ICAR), formerly known as Imperial Council of Agricultural Research, was established in 1929, in pursuance of the report of the Royal Commission on Agriculture.

JULY 18
University of Mumbai was founded in 1857.

Kadambini Ganguly, first Indian female doctor who practiced with a degree in western medicine, was born in 1861.

Rohini Satellite RS-1 was successfully launched onboard SLV-3 in 1980.

JULY 19
North Eastern Hill University was established in 1973.

JULY 20
International Moon Day.

JULY 22
Chandrayaan-2 was launched in 2019 by GSLV-Mk III - M1. It reached lunar orbit in August 2019.

Pi Approximation Day is observed as the fraction 22/7 (22nd July) is the common approximation of the mathematical constant pi.

Indian American mathematician, Shreeram Shankar Abhyankar, was born in 1930. He is known for his contributions to algebraic geometry and Abhyankar's conjecture of finite group theory.

JULY 25
Central Electro Chemical Research Institute (CECRI) was established in 1948 in Karaikudi, Tamil Nadu. Indian space scientist Nilamaber Pant, former member of the Space Commission of India, was born in 1930.

JULY 27
Indian aerospace engineer and former President of India, Dr APJ Abdul Kalam, passed away in 2015. He spent his life as a scientist and science administrator, mainly at DRDO and ISRO, and was involved in India's civilian space programme and military missile development efforts. He also played a pivotal role in India's Pokhran-II nuclear tests in 1998.

JULY 28
World Nature Conservation Day.

World Hepatitis Day.

JULY 29
International Tiger Day. Indian Association for the Cultivation of Science (IACS) was founded in 1876 by Dr Mahendra Lal Sircar to help Indians carry on fundamental research in basic sciences.

JULY 31
Indian polymath Damodar Dharmananda Kosambi was born in 1907. He contributed to genetics by introducing the Kosambi map function. In statistics, he was the first person to develop orthogonal infinite series expressions.

The Indian Academy of Science, Bangalore, founded by Sir CV Raman, was inaugurated in 1934.

— Compiled by Surbhi Agarwal and Dr Rajeev Singh, University of Delhi.

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- **Sustainable Chemical Industry**
- **Drugs & Pharmaceuticals**
- **Chemical & Polymer Engineering**

Thematic research roadmap

The roadmap aims to leverage the laboratory's scientific excellence and passion for translation along with key stakeholder connects to develop technologies for public, private, societal and strategic goods.



Central Analytical Facility (CAF)

A sophisticated analytical facility that hosts an array of state-of-the-art analytical equipment. It is dedicated to providing high-quality research and technical services, along with expertise and guidance to its users



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Chromatography Equipment
GC, GC-MS, LC-MS, MS-TOF, MALDI-TOF-MS, GPC, HTGPC, HDMS, FPLC, HRMS

BET and magnetic measurement facility
VSM, SQUID, PPMS

Biochemical Characterization
Genetic analyzer, microinjection system, SPR, FPLC

Spectrometers
UV-Vis, IR-NIR, Time-Resolved IR, Raman, Fluorescence, CD, XPS (ESCA)

X-ray Facility
Variable temperature powder and single crystal XRD, XRF, SAXS, WAXD

NMR
200 MHz (H, C), 300 MHz (Solid State-Multinuclear), 400 MHz (Solution-Multinuclear), 500.13 MHz (Solution & Solid State - Multinuclear.

National Centre for Industrial Micro-organisms (NCIM)

A national facility and microbial culture repository dedicated to isolation, preservation and distribution of authentic and industrially important microbial strains. Over 5000 microbial cultures of bacteria, fungi, yeasts and algae are available for commercial utilization.



Skill Development Program (SDP)



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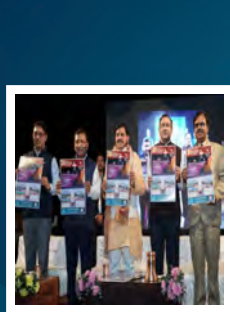
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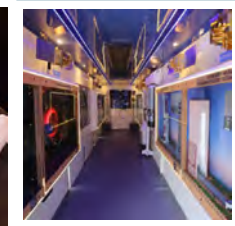












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