

VAISHAKH-JYESHTHA 1946, MAY 2024
VOL 19 ISSUE 96

www.scienceindiamag.in

PUBLISHED BY VIJNANA BHARATI
₹ 30



राष्ट्रहिताय विश्वमङ्गलाय

Connecting science and people with an Indian perspective



AN UNTOLD STORY OF 'SWARAJ'
INDIGENOUS TECHNOLOGIES:
SHAPING INDIA'S FUTURE



DIRECTOR'S MESSAGE



INST is the only institute funded by Government of India with a specific mandate of pursuing primarily nanoscience and technology and its application in agriculture, medicine, energy, water purification and sensors. The Institute has brought together outstanding scientists from different branches of science and engineering. These scientists aim to take up challenging interdisciplinary projects with a technology or device/product as the key deliverable. Research facilities have been established. Students and postdoctoral fellows have been admitted to pursue the above goals.

PROF. AMITAVA PATRA

INST MISSION

To emerge as globally competitive India's foremost research institution in Nano Science and Technology and to contribute to the society through application of nanoscience and nanotechnology in the field of agriculture, medicine, energy and environment.



- To contribute to society through application of nanoscience and technology on areas of national interest.
- To create state of the art instrumental facility for cutting edge research with outstanding scientists.
- To be able to impart advanced training courses in nanotechnology.
- To spearhead the knowledge and skill development initiatives in Chandigarh/ Punjab/ Haryana.
- To encourage patent related activities and to be a cradle for nurturing new technologies
- To enable relevant industries in neighbouring states to adopt advanced environment friendly technologies.

KEY RESEARCH AREAS



R&D FACILITIES

 SYNTHESIS LAB	 THIN FILM COATING LAB
 TISSUE CULTURE LAB	 CLASS 10000 CLEAN ROOM
 BIO-PROCESSING LAB	 NANOFABRICATION PROCESS FLOW FACILITY
 SPECTROSCOPY LAB	 LITHOGRAPHY FACILITY
 ADVANCE MATERIAL CHARACTERIZATION FACILITY	 SEMICONDUCTOR CHARACTERIZATION FACILITY
 BIO-PROCESSING LAB	 ADVANCE LASER PROCESSING AND 3D PRINTING FACILITY
 DEVICE ASSEMBLY AND TESTING FACILITY	 ADVANCE MICROSCOPY FACILITY

ACADEMICS PROGRAMME



PhD PROGRAMME

INST, Mohali has a comprehensive Ph.D. program that gives enthusiastic and motivated students the opportunity to join the highly competitive global research community. Students at INST, Mohali register for their Ph.D. degree at IISER, Mohali and ACSIR

RA PROGRAMME

INST Mohali has also vibrant Research Associate programme. Prospective candidates, who are due to submit their Ph.D. thesis or already awarded with a Ph.D. degree and having overlapping research interests with INST's Faculty members apply through this program with the faculty member concerned.

INTERNSHIPS

Institute of Nano Science and Technology, Mohali, provides an opportunity to exceptionally good undergraduate students to execute an innovative research and development project under the guidance of INST faculty

OUTREACH @INST



INST is also promoting science amongst the young generation of the nation through its outreach program especially for rural, remote and under-served schools by delivering talks in order to motivate the students to explore the world of science.

Knowledge City, Sector-81, SAS Nagar, Mohali -140306 (Punjab)

INST is India's premier institute for research & innovation in Nano Science & Technology across disciplines



@INSTMohali



+91-172-2297000



contact@inst.ac.in



www.inst.ac.in



INST Mohali

What's Inside

COVER STORY



14, 20

Image Courtesy: Shutterstock

Disruptive tech driving the world today was born in research labs, a fact that India must embrace to produce indigenous technologies.

PLUS: The riveting story of the birth of India's first indigenous tractor, aptly named Swaraj

6 Opinion

With a solid science foundation in place, India is marching ahead to become a science powerhouse

8 India's AI Vision

From acquiring AI capability to nurturing a conducive ecosystem, there's a lot taking place in this tech realm

11 AI & Architecture

A symbiotic relationship between AI and architecture is helping humans address sensitive development issues

26 Science Diplomacy

As India pushes to become a tech-driven economy, it simultaneously acquires valuable diplomatic heft

30 Hydroscience in Indian Tradition

Knowledge of our ancient seers on water, non-negotiable for survival, can teach a lot to modern hydroscience

34 Acoustics & Optics in Indian Temples

A Hindu temple utilises the power of light and sound to elevate and heighten the experience of worship

38 Identity of our Built Structures

Contemporary architecture can play an important role in instilling 'Indianness' in our built heritage

42 Science & Spirituality

SEVAN scintillators have recorded a rise in galactic cosmic ray activity during intense thought processes on earth

Cover Image Courtesy: Shutterstock



www.scienceindiamag.in

PATRONS

Prof Anil Kakodkar, Former Chairman, Atomic Energy Commission
Dr Vijay P Bhatkar, Former Chancellor, Nalanda University & Mentor, VIBHA
Prof K I Vasu, Founder President VIBHA

ADVISORY BOARD MEMBERS

Prof VPN Nampoori Emeritus Professor, Cochin University of Science & Technology
Prof T. G. Sitharam, Chairman, AICTE
Dr Shiv Kumar Sharma, National Organising Secretary, VIBHA
Shri Praveen Ramadas, National Joint Organizing Secretary, VIBHA
Shri Vivekananda Pai, Secretary, VIBHA
Dr. Arvind C. Ranade, Director, National Innovation Foundation & Secretary, VIBHA

CHIEF EDITORIAL ADVISOR

Dr Shekhar Mande, Former Director General, CSIR & President VIBHA

EDITORIAL DIRECTOR

Dr Ruchir Gupta, Associate Professor, IIT BHU
Dr Sumit Kumar Mishra, National Physical Laboratory, New Delhi

EDITOR

Debobrat Ghose

ASSOCIATE EDITOR

Sonam Singh Subhedar

DESIGN HEAD

P K Singh

PRINTED & PUBLISHED BY

Dr Sudhir S Bhadauria
Owned by Swadeshi Science Movement,
Kerala (A unit of Vijnana Bharati) Sastra
Bhawan, B 4, Fourth Floor, Mather Square,
Town Railway Station Road,
Kochi — 682 018, Kerala

ADMINISTRATIVE OFFICE SCIENCE INDIA

Vijnana Bharati Headquarters
A-4, Block A, Gulmohar Park,
New Delhi- 110049 Phone: 011-41040846

OFFICE: Manager & Advt: Vipin Rawat
Sales: Suraj Pandey
Accounts: Ankit Singh

Published from New Delhi Printed at Innovative Designers & Printers, E-41, Sector 6, Gautam Budh Nagar, Noida-201301.Tel No.: 020-4269987/ 9810145783

JAYANT MEMORIAL LECTURE JAYANTJI REMEMBERED WITH RICH TRIBUTES

Commemorating the birth anniversary of late Jayant Sahasrabudhe, the first Jayant Memorial Lecture series was organized at Prithvi Bhawan (Ministry of Earth Sciences) in New Delhi on 17 April.



Addressing the august gathering, Prof Abhay Karandikar, Secretary, Department of Science and Technology, in his keynote address on ‘Boosting Indigenous Technologies for Atmanirbhar Bharat’ said, “India’s aim to become ‘Atmanirbhar Bharat’ requires a roadmap and to achieve this goal, we have to develop indigenous technology; we need a vision for which all our scientists, our scientific institutions, and academicians need to work in tandem”.

Showcasing India’s progress in scientific innovation, Prof Karandikar shared success stories of vaccine against COVID-19, IIT-Kanpur’s consortium-based ventilator, India’s first patented single-piece 3D printed semi-cryogenic engine in space sector by a Chennai-based company and the story of 5G.

Emphasising on Intellectual Property Rights (IPR)-driven manufacturing, Karandikar added, “For making our country self-reliant, it is necessary



for us to develop an IPR-led innovation ecosystem and manufacturing system based on our intellectual property.”

Rich tributes were paid to Jayant Sahasrabudhe, the former national organizing secretary of Vibha and chief editorial advisor of *Science India* magazine. Jayantji, Jayantrao or Bhaisaab — as he was fondly addressed, left for heavenly abode on 2 June 2023, after being in coma for over eight months following a road accident.

Sunil Ambekar, Akhil Bharatiya Prachar Pramukh, Rashtriya Swayamsevak Sangh and Dr Shiv Kumar Sharma, National Organizing Secretary, Vijnana Bharati, graced the session as guests of honour. On the occasion, a calendar and a diary based on Vikram Samvat, published by Vibha, were released.



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,

Greetings from Team *Science India* on National Technology Day, which is celebrated every year in our country on 11 May, to commemorate the historic nuclear test carried out by India on this day in 1998 in Pokhran, Rajasthan. The successful testing of the nuclear bomb was code-named Operation Shakti. [The first test, code named 'Smiling Buddha', was conducted in May 1974].

Another awesome facet, which really shook the entire world the most, was meticulous planning and preparations of the conduct of the tests that escaped even the watchful and spying eyes of the self-declared cops of the world. Maintaining such a high level of secrecy itself was a cleverly planned technological feat. It was obvious that this remarkable success gave India the much needed and a truly awaited scientific and technological identity in the modern times.

The significance of this date lies not just in India achieving a rare technological feat on 11 May 1998; it lies in India's quest for scientific inquiry, technological creativity, and innovations. This spirit has never been more pronounced than it is now, when India's scientific achievements are making the world sit up and take note. Science & Technology, indeed, seem to be the zeitgeist of our times in India.

As a salute to the National Technology Day, this edition of *Science India* is a 'Tech Special'. It celebrates the scientific spirit of the country that will make India 'Viksit Bharat', with two cover stories talking at length about indigenous technologies. The untold story of India's first indigenous tractor, Swaraj, is seminal in this context, as readers will presently discover.

Of special importance is an analysis on how technological prowess is adding valuable heft to India's diplomatic arsenal. Read all about it in the 'Science Diplomacy' column.

There is also an analysis of how *Nature*, the well-known international journal of science, has predicted India as a rising star on the horizon of science and technology.

India's pre-colonial history is rich with instances of indigenous technology in a variety of sectors, which are now being revived and propped up by new technologies. This edition carries a whole gamut of stories looking at technological advancements in different areas — from ancient Indian wisdom of water conservation to highly scientific temple architecture with well-delineated acoustics, climate control and other characteristics, there is a lot of food for thought.

There are also special stories on the new buzzword of contemporary times — Artificial Intelligence or AI.

In this season of elections, *Science India* brings a quick explainer on the science behind the most important mark that we will carry on our fingers for weeks after the Lok Sabha polls are over — the mark of the indelible ink that is the strongest proof of citizens exercising their right to vote, and to be an active part of the world's most dynamic and largest democracy.

By the time we meet next month, India would be on the verge of swearing in the newly elected members of the 18th Lok Sabha, to inaugurate yet another chapter of democracy in the most diverse and ancient nation of the world, in which, science and technology will be poised to play an ever-increasing role.

As a salute to the National Technology Day, this edition of *Science India* is a 'Tech Special'. It celebrates the scientific spirit of the country that will make India 'Viksit Bharat'.

India Building a Science Supertall on a Solid Foundation

It is no longer a question of ‘when’ and ‘how’; India is already on the path to become a science powerhouse



■ Debobrat Ghose

While the world’s most populous democracy, India conducts its biggest Lok Sabha election, the editorial piece in the reputed science journal *Nature* – ‘How India can become a science powerhouse’, means a lot for the current dispensation, the Narendra Modi government and its work.

However, not delving into its political aspect, let’s see this headline through the prism of science.

It is welcoming and satisfying that the international journal of science, *Nature*, has prognosticated in its edition of 18 April that India has the potential to become a leader in science. If we take a deep dive into our ancient history, we find India as a superpower in the field

of education, science and technology. It had many ‘firsts’ to its credit — from the invention of wootz steel to the invention of zero, the list is exhaustive.

But simultaneously, it’s also true that today India no longer needs validation from the West. There was an India in the Sixties, Seventies and Eighties, when anything with a ‘foreign’ tag was almost an obsession and many of us took pride in possessing a foreign brand — be it a chewing gum, watch, perfume, a pair of jeans or a ‘phoren’-returned guy.

In the 21st century India, however, this obsession has minimized. Today’s India is about self-reliant India, a confident India and the India that has taken responsibility on its shoulders to be on the global stage through its work. During the COVID-19 pandemic, when the world assumed that India would have great difficulty in fighting the crisis, we were one of the few countries to develop an indigenous vaccine and a foolproof system of vaccine delivery based on technology. Besides administering 220 crore doses all over the country, India under its Vaccine Maitri programme exported

30.1 crore doses and became the third largest Covid vaccine exporter in the world after China and Russia.

To reach this stage of self-confidence, India had to undertake an arduous journey — from breaking the shackles of subjugation, oppression and extreme discrimination under the British rule, to slowly rebuilding the lost confidence in our own merit, and finally competing with confidence on the world stage.

According to the World GDP Ranking 2024 list, India is the fifth largest economy in the world, and also the fastest growing.

While India is aiming at a \$5 trillion economy by 2025, it’s also a historical truth that the British had siphoned off a whopping sum of \$45 trillion in 190 years — nine times to what we are aiming today. To fuel its Industrial Revolution in England, the British looted 38-million-pound sterling between 1757-80 from Bengal alone.

The 190 years of the British Raj (including the East India Company’s rule in Bengal and subsequently in India) was a saga of great loot. This loot impacted

India's education and its indigenous progress in science and technology. In fact, Indians were made to believe that their knowledge of science and technology was much inferior.

Citing an example: The British looted Kohinoor diamond from India and kept it on display for the world to see; today it is on display at the Tower of London. And for that they charge £32 per visitor!

If *Nature* says India has the potential to be a 'science powerhouse', it has taken this nation a lot of gumption to reach this stage. Even before Independence, when this country was fighting the British for its freedom, our stalwart scientists like Acharya Jagadish Chandra Bose, Acharya Prafulla Chandra Ray, Dr Mahendra Lal Sircar, Ruchi Ram Sahni, Sir CV Raman, Satyendra Nath Bose, to name just a few — had world-class achievements, though the West chose to ignore them. Some of their works deserved the Nobel Prize but it was never conferred on them.

Raman was an exception in that sense. He was the first Indian and the first Asian to win the Nobel Prize in any discipline of science (Physics) — a true indigenous scientist, who did his research in India's first indigenous lab — the Indian Association for Cultivation of

Science (IACS) in Calcutta, which was founded by Dr Sircar for Indian scientists to carry out indigenous research. Raman also created a mini laboratory inside his house in the bylanes of central Calcutta's Premchand Boral street, so that he could continue with his experiments when at home.

Today, when we talk of developing indigenous technologies, we also need the scientific temperament, tenacity and perseverance of Raman, who did it as a colonial subject, facing all odds that existed in those days of British rule.

Let's not forget that the British government was never favourably disposed towards Indian science and scientists. In fact, they dismissed our science as 'unscientific' and 'superstitious' in nature. Getting funds for research from the colonial masters was virtually next to impossible. Many Indian scientists and inventors even failed to get their due in pre-Independent India.

Today, we are fortunate enough to have a massive chain of CSIR labs, besides Indian Institute of Science and Indian Institutes of Technology. A big credit for this goes to Dr Shanti Swarup Bhatnagar (1894-1955), the founder-director of CSIR (Council of Scientific and Industrial Research), who played a seminal role in helping build indepen-

dent India's science and technology infrastructure; he established 12 national laboratories in his lifetime.

India is only behind the United States and China in terms of research output in the world. Our government has increased the expenditure on Research and Development (R&D). The Gross Expenditure on R&D, which was Rs 60,196 crore in 2010-11 has doubled to Rs 1,27,380 crore in 2020-2021.

This also says a lot about the political will of the present government.

In context to R&D spending, the *Nature* article has pointed out that 60% of India's research spending comes from central and state governments, and universities; and private sector's contribution is 40%; whereas the other economies similar to India have much more private sector funding.

Last year, the government established a funding agency for scientific research — Anusandhan National Research Foundation (ANRF). The ANRF aims to seed, grow, and promote research and development (R&D) and foster a culture of research and innovation throughout India's universities, colleges, research institutions, and R&D laboratories. The budget has envisaged a spending of Rs 50,000 crores over five years, out of which a major share of Rs 36,000 crores, is estimated to come from non-government sources, from industry and philanthropists, from domestic as well as outside sources.

ANRF will act as an apex body to provide high-level strategic direction of scientific research in the country, forge collaborations among the industry, academia, and government departments and research institutions.

The ANRF will prove to be a significant milestone in India's scientific research and innovation ecosystem, where the private sector funding will play a big role.

Today, India is fearless and is already on a superhighway with its head held high, as Gurudev Rabindranath Tagore said, "Where the mind is without fear; And the head is held high".

**The writer is Editor, Science India.*



Image Courtesy: Sonam Singh Subhedar

Council of Scientific and Industrial Research, New Delhi. Its founder director Dr Shanti Swarup Bhatnagar created a network of 12 labs in his lifetime



“We need to make AI in India and AI work for India”
 – Prime Minister Narendra Modi on his vision of ‘AI for All.’

India’s AI Vision

From acquiring capability in AI usage to nurturing a focussed AI ecosystem, there is a lot taking place in the realm of the newest transformative tech to take civilisation by storm



■ Dr Udaya Shankar Puranik

India’s foray into the realm of Artificial Intelligence (AI) has been envisioned as an umbrella programme by the Ministry of Electronics and Information Technology (MeitY) for leveraging transformative technologies to foster inclusion, innovation and adoption for social Impact.

For the past 10 years, the government of India has encouraged the development of AI-based solutions to address the problems faced by the common man. These include AI solutions that can help in early detection of diseases, increase

agricultural productivity, and promote linguistic diversity.

AI IN AGRICULTURE

India’s agriculture sector sustains the livelihoods of millions while facing significant challenges. With a vast and diverse landscape, varying climate conditions, and a predominantly smallholder farming model, Indian agriculture encounters issues such as yield variability, resource inefficiency, and post-harvest losses. However, the introduction of AI-led technologies holds immense promise to revolutionize this sector.

By leveraging AI’s capabilities in data analysis, predictive modelling, and precision farming, Indian farmers can gain insights into localized weather patterns, optimal planting times, and resource allocation, leading to improved crop yields and reduced waste. AI-powered solutions can help address these longstanding challenges, enhancing the

sustainability and productivity of Indian agriculture while ensuring food security for its growing population.

Artificial Intelligence is poised to drive a transformative shift in agriculture, fostering innovation and sustainable development. The agricultural sector is expected to be the second major segment by 2025. Niti Aayog has adopted the nurturing of AI ecosystem in India and welcomed a theme of ‘AI for all’.

Pune-based agritech startup Farm-pal has designed an AI solution to predict demand and matching farmers supply data to keep wastage below 5 per cent. According to the company, “Post-harvest supply chain is currently completely unorganised, which is causing wastage of about 30-40 per cent of the farm produce. One of the major reasons is that the stakeholders do not have data on the demand and supply. The biggest challenge is predicting consumer

Image Courtesy: ai-q.in

demand and matching available supply, so there is no over- or under-supply, resulting in minimum wastage across the value chain.”

“AI modules help us to understand weekly demand for more than 50 stock-keeping units. This helps us to inform demand to the farmers a week before, and farmers can plan harvesting based on the demand to avoid over- as well as under-supply. Thus, we can sell at about 95 per cent accuracy and in turn, lower the wastage to less than 5 per cent across the value chain,” claims the company.

Through precision agriculture, resource optimization, supply chain



Image Courtesy: Peerless Hospital

Above: Peerless Hospital launched Humanoid Robotics for the first time in Eastern India, for hip, knee and shoulder replacement with 3D robotics



Image Courtesy: Shutterstock

an artificial implant with surgical instruments. The entire process is manual and thus, prone to human errors,” he stated.

In the AI-based system for knee replacement surgery, CT scan of a patient’s damaged joint and leg is sent into the HoloLens augmented reality system. A computer programme assists in determining the patient’s proper alignment. Throughout the procedure, the surgeon wears HoloLens. Without using the robotic arm, the surgeon can confirm the incisions and attain the appropriate alignment.

“The surgeon wears the HoloLens. It enables the surgeon to see the entire limb. Earlier, during knee replacement, we could only see the front portion of the knee. There was no vision of the hip, ankle or leg. The new system provides a holographic image generated by AI that gives the surgeon a much better and holistic view of the entire limb,” stated Mukherjee. Another benefit of the new technology, explained by Dr Somnath De, the hospital’s clinical director and senior orthopaedic surgeon, is: “The technology helps achieve personalised alignment with the freedom to use the implant best suited for that patient. Robotic surgery, however, allows only specific implants that match the particular robotic make.” The new

enhancement, and empowerment of smallholder farmers, AI is addressing challenges that have persisted for generations. As the world’s population continues to grow, harnessing the power of AI in agriculture becomes more imperative than ever before. By embracing AI-driven solutions, the agricultural sector can pave the way for a future where food security is assured, resources are conserved, and rural economies thrive.

AI IN HEALTHCARE

In India, a shortage of more than 100,000 eye doctors, and the fact that only 6 million out of 72 million people with diabetes are screened for diabetic eye disease, mean that many individuals go undiagnosed and untreated.

Google and Verily—Alphabet’s life

sciences and healthcare arm—have developed a machine learning algorithm to make it easier to screen for the disease, as well as expand access to screening for Diabetic Retinopathy (DR) and Diabetic Macular Edema (DME)—two of the leading causes of preventable blindness in adults). The first real world clinical use of the algorithm was done at the Aravind Eye Hospital in Madurai, India.

Recently, AI was used by doctors for knee replacement surgery in Peerless Hospital, Kolkata. Dr Sudipta Mukherjee, a senior physician in the orthopaedics and traumatology department of the hospital, and an orthopaedic surgeon, outlined its benefits over the current approaches.

“In the conventional method of knee surgery, the doctor replaces a joint with

AI-based method is said to be less expensive than robotic surgery, since a typical robotic arm costs around Rs 6 crore, while a HoloLens costs Rs 20 lakh.

AI IN FINTECH

The collaboration between the Reserve Bank Innovation Hub (RBIH) and Digital India Bhashini Division (DIBD) aims at breaking down the language barriers prevalent in the financial services landscape. This collaboration arises against the backdrop of a transforming fintech sector, driven by increased smartphone penetration and reduced data usage costs. As a significant initial step, Bhashini plans to launch a Public Tech Platform for Frictionless Credit in multiple languages. This platform aims to streamline and enhance credit delivery by financial institutions, contributing significantly to greater financial inclusion.

While these advancements have propelled the country's financial inclusion endeavours, specific sectors and segments of the population remain on the fringes of the formal financial sector. This collaboration signifies a pivotal stride toward integrating them into the established financial ecosystem.

AI FOR YOUTH

PAiGPT is India's first AI-powered conversational chatbot for UPSC aspirants. The bot is now available on Android and iOS. The app aims to revolutionise the aspirants' research and learning experience for the government exam.

PAiGPT was developed by Pinak Ai, a bootstrapped Indian company harnessing the power of generative AI and democratising technology for non-urban areas. PAiGPT is seamless and affordable for everyone. The app can fetch real-time information on various topics and current affairs.

Though the app's functioning is similar to Perplexity AI and Google Gemini, PAiGPT's ability to provide trending topics and the option to create multiple-choice questions based on the available information makes it relevant for UPSC aspirants. Students can even

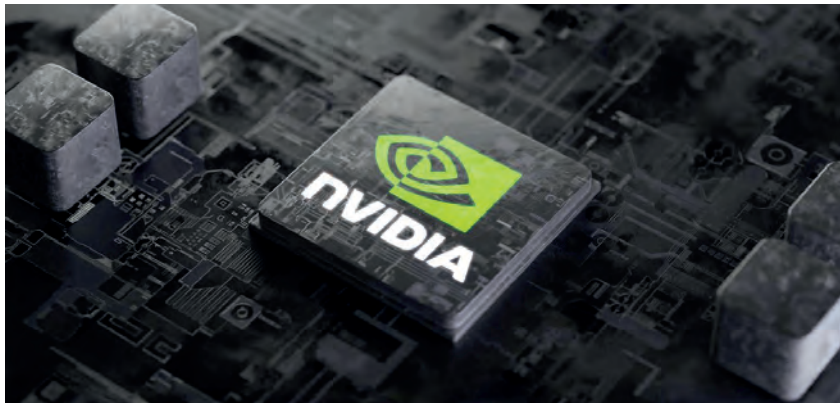


Image Courtesy: Internet

The Government of India is exploring partnership with chip-making giant NVIDIA to procure GPUs and NPUs and offer them at subsidised rates to local startups, researchers, academic institutions, and other users to boost AI infrastructure

upload images of editorials from popular newspapers, and the app can generate summaries.

The developers are also planning to introduce a feature that will allow the app to generate summaries in Hindi, even if the uploaded image contains text in English.

AI ECOSYSTEM IN INDIA

India's AI mission aims not only to foster innovation but also to safeguard the sovereignty of Indian data. Due to the limited availability of GPUs (Graphics Processing Units) domestically, many companies have resorted to accessing cloud resources located abroad.

In March, the Government of India approved budget of Rs 10,372-crore for India's AI Mission with an aim to deploy 10,000 GPUs through public-private partnerships. Under the rent-and-sublet model, the government plans to provide GPUs to qualifying startups, researchers, and others on a concession basis.

Alternatively, a marketplace model is being considered, where performance can be objectively measured, and incentives distributed accordingly, similar to a production-linked incentive (PLI) scheme.

The scarcity and high cost of GPUs have made acquiring them a significant challenge for companies, especially startups in India. Typically, NVIDIA's H100 GPUs would go for about \$50,000 a piece, whereas its more recent Blackwell cards go for about \$40,000.

Even for the most basic AI data centre that is only capable of running existing AI models, requirement would be 100 to 300 GPUs. For any meaningful computing capability that could be used to create, develop and train large language models, requirement would be 5000-10,000 GPUs.

So, the government of India is exploring potential partnership with chip-making giant NVIDIA to procure GPUs and NPUs (Neural Processing Units) and offer them at subsidised rates to local startups, researchers, academic institutions, and other users in a bid to boost the AI infrastructure in India.

AIRAWAT, the AI Supercomputer of India, which is located at CDAC in Pune, was ranked 75th among the top 500 supercomputers of the world. This ranking was announced at the International Supercomputing Conference (ISC) 2023 held in Germany.

The government of India has implemented several programs to enable students at different levels to learn AI skills. The New Education Policy (NEP) is a game changer in adopting new technologies like AI in our education system and also building capability in AI at all levels of education across the country.

**The writer has 37 years' experience in the fields of global AI and Cyber Security. He is a science and technology writer with more than 4000 published articles to his credit.*

He can be reached at upuranik@gmail.com.

Use of AI helped Foster + Partners to optimize energy-efficient design for Bloomberg European Headquarters in London

AI & Architecture: A Symbiotic Relationship

By integrating AI into their work, architects can create smarter, greener, and more resilient built environments for India's evolving needs



■ Ar Sanjay Bhandari

Artificial intelligence (AI) is not merely a buzzword; it's a transformative force reshaping industries across the globe. From healthcare to finance, its applications are vast and its potential, boundless. However, one domain where AI's impact is particularly profound and promising is architecture.

As we navigate towards the horizon of Viksit Bharat@ 2047, AI emerges as a crucial tool in the narrative of architectural evolution and innovation. During a summit on Global Partnership on Artificial Intelligence held in New Delhi on 12 December 2023, Prime Minister Narendra Modi underscored India's unwavering commitment to the responsible and ethical use of AI. In the next two decades, AI is poised to revolutionize the architectural landscape.

AI TO SUPPORT, NOT DISPLACE ARCHITECTS

While AI holds immense promise in augmenting architects' capabilities across

various domains such as design optimization, environmental analysis, and project management, it is unlikely to completely supplant human architects. The essence of architecture lies in the unique blend of human creativity, intuition, and a nuanced understanding of cultural and societal contexts—elements that are challenging for AI to replicate. These qualities instil architectural creations with meaning, identity, and a sense of belonging within their environments. Rather than displacing architects, AI is ready to serve as a powerful tool to complement their expertise. By leveraging AI's analytical prowess and computational capabilities, architects

can delve deeper into design exploration, informed by data-driven insights. Additionally, AI can streamline routine tasks and logistical challenges, enabling architects to devote more time and energy to design, conceptualization and innovation.

In essence, the future of architecture lies in the symbiotic relationship between human ingenuity and technological advancement. While AI holds the potential to enhance efficiency and offer new avenues for exploration, it is the collaboration between human architects and AI that will ultimately shape the architectural landscape of tomorrow.

At its core, AI encompasses a spectrum of disciplines, amalgamating mathematical logic, computational neurobiology, and computer science with the overarching goal of replicating human cognitive functions. This evolution, deeply intertwined with advancements in computing, empowers machines to undertake tasks that were once exclusively human territory. The integration of computational tools in architectural design involves leveraging parametric relationships, self-organizing processes, and algorithms to generate designs with minimal human intervention. This approach underscores the pivotal role of shape exploration in the conceptual design phase, shaping subsequent stages of the design process, construction, and the building's life cycle.

AI INTERVENTIONS IN ARCHITECTURE

Architectural design focuses on shaping a building's form, which is crucial in the creative process. Architects often find inspiration in nature. Creativity involves a lot of brainstorming, critical thinking, and exploration, making the process iterative. Some AI techniques, like fractal geometry and swarm intelligence, mimic natural forms and movements to aid in design. This approach, highlighted in a recent research, promotes forward-thinking in architecture, blending diverse ideas to create innovative and sustainable designs. The integration of AI technologies such as Generative Adversarial Networks (GANs) allows architects to generate multiple design so-



Image Courtesy: wallpaperhub

World renowned Zaha Hadid Architects used AI algorithms to design the Beijing Daxing International Airport that has an innovative starfish design

lutions automatically, based on specific parameters like building dimensions and energy consumption. Additionally, advancements in Virtual Reality (VR) and Augmented Reality (AR) have transformed architectural visualization, offering immersive presentations that go beyond traditional 2D drawings and 3D models.

AI-driven predictive analytics facilitate informed decision-making from the early stages of design, enabling architects to anticipate energy consumption patterns and sustainability indicators across different design scenarios. Furthermore, AI-powered risk assessment tools offer valuable insights into regulatory compliance and potential hazards, enhancing the safety and resilience of architectural projects.

Leading architectural firms of the world have embraced AI to enhance their design processes, exemplified by Zaha Hadid Architects' use of AI algorithms to design the Beijing Daxing International Airport and Foster + Partners' optimization of energy-efficient designs for projects like the Bloomberg European Headquarters in London.

Advancements in Virtual Reality (VR) and Augmented Reality (AR) have transformed architectural visualisation

In addition to renowned architectural firms, innovative AI-based tools and platforms have emerged to democratize access to architectural design capabilities. For instance, a firm based in Australia offers a comprehensive solution for architects and universities, streamlining site analysis and design generation processes while providing educational resources through its online academy. Tools like Hypar and Delve leverage machine learning to expedite early concept design, while AI integration with popular architectural software like Revit, Rhino, and Grasshopper enhances workflow efficiency and design precision.

The integration of artificial intelligence (AI) into various software applications has significantly transformed the landscape of architectural practice. Across different disciplines within the field, AI-powered tools are revolutionizing traditional processes and enabling architects to design and manage projects with unprecedented efficiency and precision. One such example is Click Up, a project management tool that has gained widespread adoption not only in architecture but across multiple industries. This cloud-based application has emerged as a 'secret weapon' for architects, offering features specifically tailored to enhance workflow efficiency. Click Up seamlessly organizes and tracks projects, harmonizing tasks, deadlines, and team assignments on a

simple platform. By ensuring smooth project progression from the initial design phase to construction, Click Up helps architects avoid missed deadlines and maintain momentum throughout the project lifecycle.

In addition to project management, AI-powered tools are also making significant strides in the realm of design and planning. Autodesk Forma, for instance, has carved a niche for itself as an all-encompassing AI-powered planning tool. Designed to assist architects and urban planners in crafting sustainable and livable cities, Autodesk Forma harnesses the power of AI to simulate the implications of various design decisions on critical factors such as energy consumption, traffic flow, and air quality. By providing insights into these crucial aspects, Autodesk Forma empowers designers to make more informed and sustainable design choices, ultimately enhancing the

the preservation of sensitive artworks, archaeological items, and cultural heritage sites. Moreover, there is the potential for AI to facilitate the digitization and documentation of cultural heritage assets through automated scanning, 3D modeling, and virtual reality applications.

These technologies have the potential to enable conservation professionals to create precise digital replicas of historical artifacts and places, ensuring their preservation in digital form and safeguarding them from physical damage or loss. In research and architectural writing, AI-based tools have emerged as invaluable resources for accelerating literature surveys and literature reviews. Tools like Elicit, Research Rabbit, and Scite leverage natural language processing (NLP) algorithms and machine learning to extract key insights from research papers, automate citation man-

use of AI to develop advanced materials such as a new type of concrete that promises enhanced durability and sustainability. School of Planning and Architecture (SPAs) has already initiated courses on the role of AI in architecture and planning, equipping students with essential skills for future industry demands. These courses aim to integrate AI technologies into architectural practices, fostering innovation and sustainability in the built environment. Additionally, Indian startups like Spacetime are leveraging AI-powered software to assist architects and engineers in designing more efficient and sustainable buildings. Smart Cities Technologies are at the forefront of developing AI-powered solutions for smart buildings, aimed at reducing energy consumption, improving safety, and enhancing occupant comfort.

While AI adoption in the Indian architecture industry is still in its nascent stages, its potential for transformative impact is immense. The rise of AI presents a promising opportunity for architects in India to enhance their knowledge and skills, contributing to the creation of more sustainable futures for cities, towns, and villages across the country. By embracing AI concepts and technologies, architects can expand their understanding of innovative design approaches and efficient construction practices. With AI-powered tools at their disposal, architects can explore new possibilities for urban planning, resource optimization, and environmental conservation. By integrating AI into their workflows, architects can create smarter, greener, and more resilient built environments that cater to the evolving needs of India's diverse communities. As AI technology continues to evolve, we can anticipate even more innovative and game-changing applications of AI in architecture, further revolutionizing the way buildings are designed, constructed, and operated in India.

**The writer is Assistant Professor, Department of Architecture, School of Planning and Architecture, Vijayawada.*

AI brings significant advantages to architects in terms of efficiency, creativity, etc., but also poses ethical dilemmas, potential biases, and concerns regarding human element

sustainability and liveability of architectural projects. Moreover, Autodesk Forma is equipped with the capability to identify potential design flaws before implementation, thereby mitigating the risk of costly rectifications in the future.

The convergence of AI and Building Information Modeling (BIM) in tools like Bricscad (Smarter CAD with AI) can potentially reshape the architectural design process. While BIM already enables architects to encapsulate the architecture, engineering, and construction aspects of a building within a 3D model, the integration of AI functionalities in BricsCAD BIM will amplify these capabilities even further. In the domain of heritage conservation, there is the possibility that AI algorithms could play a pivotal role in identifying damage, formulating restoration plans, and monitoring environmental impacts. By leveraging image recognition, pattern detection, and data analytics, AI has the potential to contribute significantly to

agement, and evaluate the credibility of scholarly works, thereby enhancing the efficiency and quality of research endeavours.

WHITHER HUMAN ELEMENT?

While AI brings significant advantages to architects in terms of efficiency, creativity, and environmental responsibility, it also poses ethical dilemmas, potential biases, and concerns regarding the human element in design. Therefore, architects have a challenge to carefully navigate the integration of AI, weighing its benefits and drawbacks, and striving to strike a harmonious balance between technological progress and design principles centered on architectural knowledge systems, human needs and experiences. AI has already made significant inroads into the architectural design, development, and construction industry in India.

Institutions like the Indian Institute of Technology, Delhi are pioneering the



INDIGENOUS TECHNOLOGY FOR VIKSIT BHARAT

Disruptive technologies driving the world today were born in research labs, a fact that India must embrace to produce technologies in the country's laboratories to transition from 'developing' to a 'developed' nation



■ Prof B N Jagatap

Since 1987, India has been celebrating National Science Day (NSD) on February 28 of every year. NSD is meant for emphasizing the role of science in national development and for showcasing the country's achievements in science and technology. Starting from 1997, NSD celebration has been made thematic.

Themes for NSD have been contextual and they are intended to sensitize people on the impending challenges which demand

scientific and technological solutions. In 2024, the theme for NSD was, 'Indigenous Technology for Viksit Bharat'. The phrase 'indigenous technology' literally means technological knowledge and skills used by indigenous people to meet their needs. The dictionary meaning of the word 'indigenization' is an action or process of bringing something under control of the people native to an area. In line with this meaning, in the Indian S&T sector, the word indigenous is used to denote local or home-grown technology as against the imported technology. This meaning is implied in the statement of the Department of Science and Technology: "The theme represents a strategic focus on promoting public appreciation for science, technology and innovation, and accomplishments of Indian scientists to address challenges through home-grown technologies for

overall well-being.”

History has repeatedly shown that technology is indeed essential for rapid development of any society. While a country can acquire technology in a variety of ways, what matters in actual terms is the technology it owns. It is the indigenous technology that protects it from international protectionism and ever escalating geopolitical tensions. The theme is, therefore, extremely relevant and important for India to make the transition from ‘developing’ to ‘developed’ country.

MODES OF ACQUISITION OF TECHNOLOGY

A country can acquire technology in a number of ways. In 2013, I was fortunate to listen to Prof G Sundararajan of ARCI, Hyderabad (International Advanced Research Centre for Powder Metallurgy and New Materials), who described various modes of technology acquisition, and their pros and cons as follows:

Trade is the most elementary mode of technology acquisition. This relates to high technology products that are sold in India. Here, the technology details such as materials, processes and assembly are completely hidden. Foreign Direct Investment (FDI) is a mode in which a foreign company sets up a manufacturing unit for a product based on its technology. In this case, the technology is visible but not available for exploitation. In Joint Venture, a foreign company with its technology sets up a production plant jointly with an Indian entity which operates the plant and markets the products. Here, too, the technology is not available for exploitation. In the Buyback Agreement, a foreign original equipment manufacturer (OEM) helps an Indian company to set up a component production plant and buys back the product. In this case, technology is given to an Indian entity which does incremental innovation to reduce cost and increase quality; however, these are constrained by OEM requirements. The most common mode of acquisition of technology is through license from a foreign company. Here,

an Indian company sets up a production plant based on the know-how provided by a foreign company. The technology details are known, but further improvement of the technology is not possible. In all these modes of technology acquisition, there exists no scope for the Indian company to expand outside India.

Indigenous technology implies that an Indian entity develops technology on its own and sets up a production plant or licenses it to other Indian entities. Here, the technology details are known and there is always a scope for further upgradation and for expanding business outside India. Another variation of this situation is collaboration between Indian industry and Indian research institutes

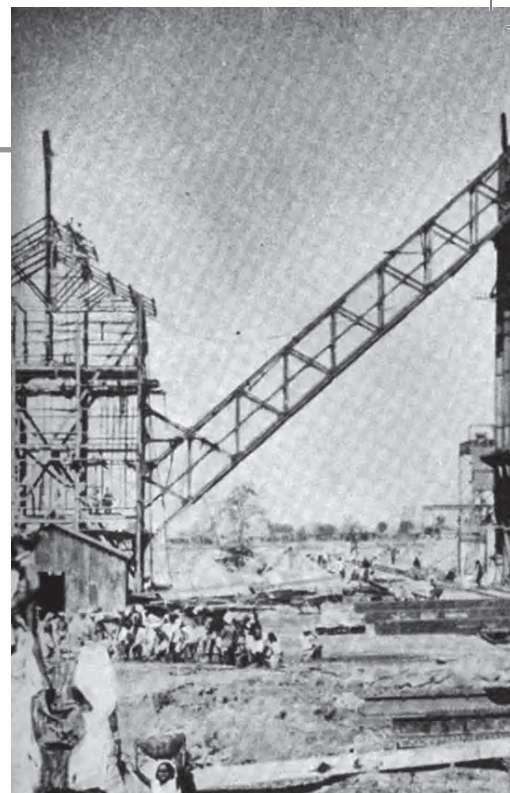


Image Courtesy: Tata.com



Image Courtesy: Internet

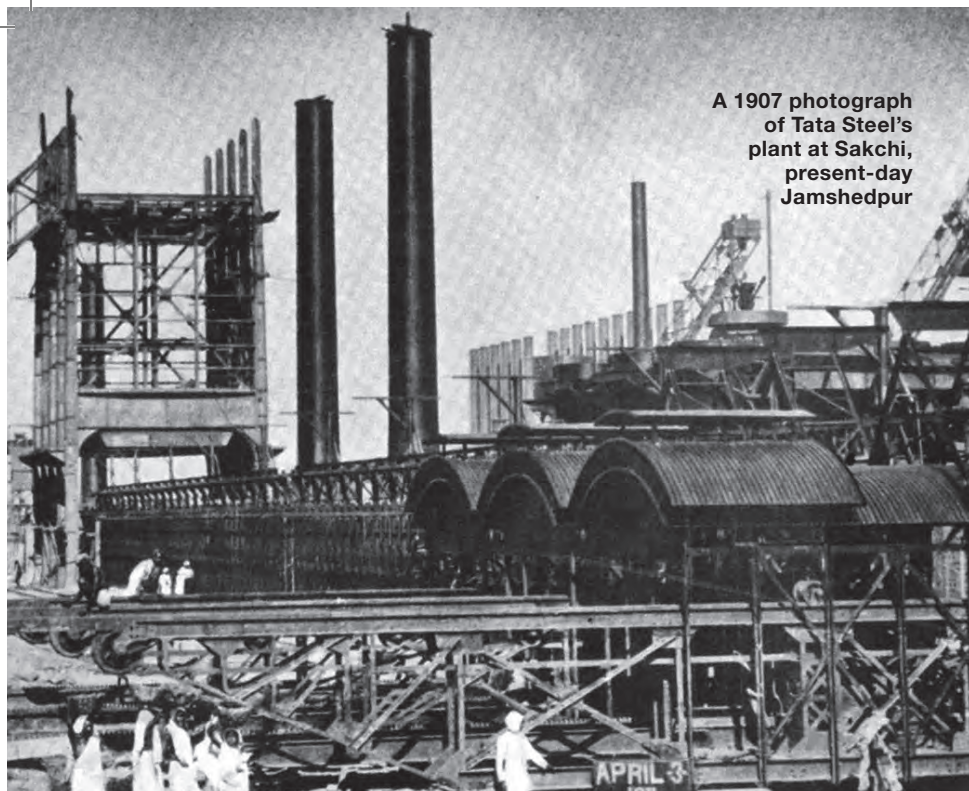
The 1974 Pokhran test, being inspected by then Prime Minister Indira Gandhi, brought India under international sanctions but also started the second phase of technology development, which was articulated in the S&T Policy of 1983

for development of a technology. India needs such indigenous technologies that are Indian in terms of design, materials and assembly.

INDIGENOUS TECHNOLOGIES OF ANCIENT INDIA

Ancient India was known for her home-grown technologies for a very long time. Technologies for production of rust-less iron and crucible iron (wootz) were developed way back in the 4th century BCE. India also developed mature technologies for zinc and copper metal produc-

tion. Indian steel was exported to the Arab world and Europe for making the famed Damascus swords. High quality Indian steel was exported to England as late as the 19th century. The production capacity was almost semi-industrial; for example, zinc smelting operations at Zawar produced one lakh tons of metallic zinc during 13th-18th century. Indian technologies inspired European researchers; for example, D Mushet took a patent for carbon steel in 1800 and his process was similar to what ancient Indians used for making their wootz. In 1740, William



A 1907 photograph of Tata Steel's plant at Sakchi, present-day Jamshedpur

dustry. But the destiny of those industries would inevitably be decided by what transpired in the laboratory. The laboratory was thus in the final reckoning place where the world's artistic and industrial triumph would be won."

While remembering the scientists of pre-independence India, we seldom appreciate that many of them had a grand dream of rejuvenating indigenous industry using modern science and technology. Take for example, Acharya Prafulla Chandra Ray, who founded the Bengal Chemicals and Pharmaceutical Works in 1892 and developed it as a successful enterprise. He was also associated with many other commercial ventures such as Bengal potteries, Bengal enamel, National tanneries, etc. Contribution of Pramatha Nath Bose in the establishment of Tata Iron and Steel Works at Sakchi in 1907 is well known. Ruchi Ram Sahni established a unit for manufacturing of scientific equipment at Punjab Science Institute in 1887 and further went on to establish a sulphuric acid factory in 1914. TK Gujjar, who developed a medicine for plague, established Alembic Chemical Works at Baroda in 1907 under the patronage of Maharaja of Baroda. Renowned civil engineer Sir M Visvesvaraya's contributions to development of indigenous technology and industry are too well known. Notable amongst them are automatic weir water floodgate system for Khadakwasala dam, flood protection system for Hyderabad, water supply and drainage system at Aden, Mysore soap factory, Mysore Iron and Steel works, etc. Shankar Abaji Bhise, known as the Edison of India, had over 200 inventions and over 40 patents. It is worth mentioning that the spectrometer of CV Raman was an indigenous instrument, however, Indian scientists of later years did not commercialize it.

JOURNEY POST-INDEPENDENCE

India's independence in 1947 was on the backdrop of a number of world events which shaped the progress of technology in later years. The end of World War II in 1945 had demonstrated successful war efforts backed by high end technology. The Manhattan project had shown



Image Courtesy: Wikimedia Commons

Left: Inventor Shankar Abaji Bhise (1867-1935), also known 'Edison of India', had over 200 inventions and over 40 patents

the protectionist British policies decimated indigenous industry all together. The effect of this destruction was perhaps the largest in Bengal; its indigenous cotton industry could not cope with the onslaught of the cotton industry of Manchester. This is where probably the seeds of the Indian science movement were sown.

Dr Mahendra Lal Sircar started a campaign for a national science association and established the Indian Association of Cultivation of Science (IACS) in 1876. The objective of this association was stated clearly by him in the annual report of 1890 of IACS. He said: "Competition between the nations of the earth, which every passing year became fierce. Survival depended on making the most of the material resources by efficient in-

This technological change together with the protectionist British policies decimated indigenous industry all together. The effect of this destruction was perhaps the largest in Bengal

Champion established zinc metal production at Bristol based on the downward distillation process of Zawar.

High quality fabric produced by Indian weavers was in demand all over the world from the days of Indus civilization. Ancient India also excelled in ship building ever since the inhabitants of Indus civilization established trading contact with Mesopotamia. These and many other technologies of ancient India brought immense prosperity and made it indeed Viksit.

DESTRUCTION AND REBUILDING DURING BRITISH RULE

In the British period, India's indigenous industry faced a steep challenge from the European industry which had started using steam power for mass production. This technological change together with

TK Gujjar, who developed a medicine for plague, established Alembic Chemical Works (right) at Baroda in 1907

the way for institutionalization of S&T. WWII was followed by the 'Cold War' which was basically a technological race for military superiority. Technological progress was so captivating that India did not remain untouched by the new turn of events on the world stage. The newly independent nation, thus, had to balance between technologies for socioeconomic development and the technologies emerging out of WWII and the cold war.

In the first two decades or so after Independence, India received technology inputs from USA, Canada, UK, France and USSR through intergovernmental agreements. Indian scientists and engineers worked with these inputs and brought in some sort of self-sufficiency in select sectors of economy and strategic areas. In fact, the Green Revolution in India started with the agricultural technology pioneered by Norman Borlaug in Mexico. Foreign collaborations, thus, shaped the initial trajectory of technology development in India. This is not to take away credit from Indian scientists and technologists, however, the mute question is whether to call such technologies of that phase indigenous or not.

The Pokhran nuclear test in 1974

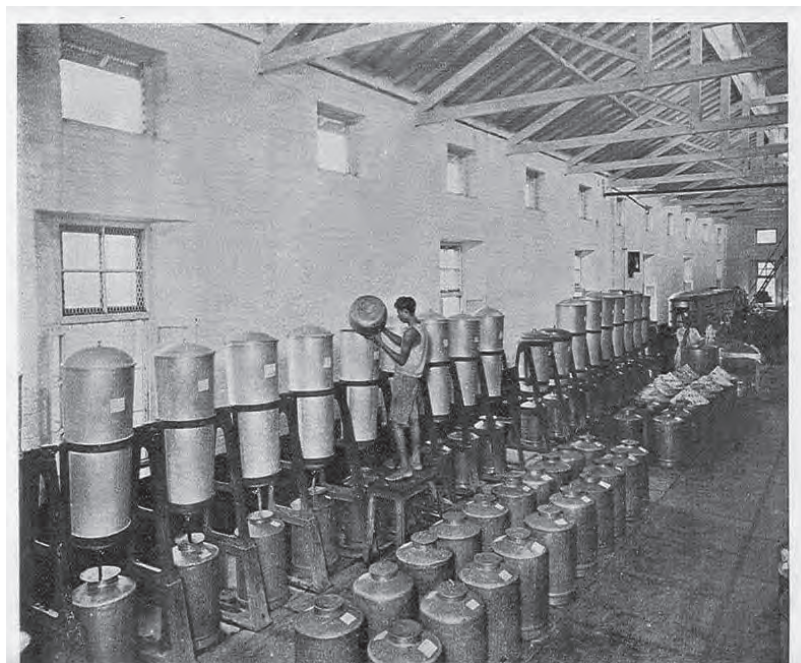


Image Courtesy: Alembicusa.com

brought India under international sanctions and ended international cooperation. This started the second phase of technology development, which was articulated in the S&T Policy of 1983. Some key points were: Attaining technological competence and self-reliance to reduce vulnerability in strategic and critical areas; development and absorption of indigenous technology and adaptation of select imported technology appropriate to national priorities and resources; and

development of internationally competitive technologies with export potential.

The hallmark of this phase was the buzzword, 'import substitute', i.e., a technology that substitutes foreign technology. During this phase significant efforts were spent in developing indigenous technologies. Development of low- and high-end scientific instruments was also taken up in this phase. Due to international sanctions and supply chain disruption, the technologies developed in this

A conference at Alembic Chemical Works, Baroda

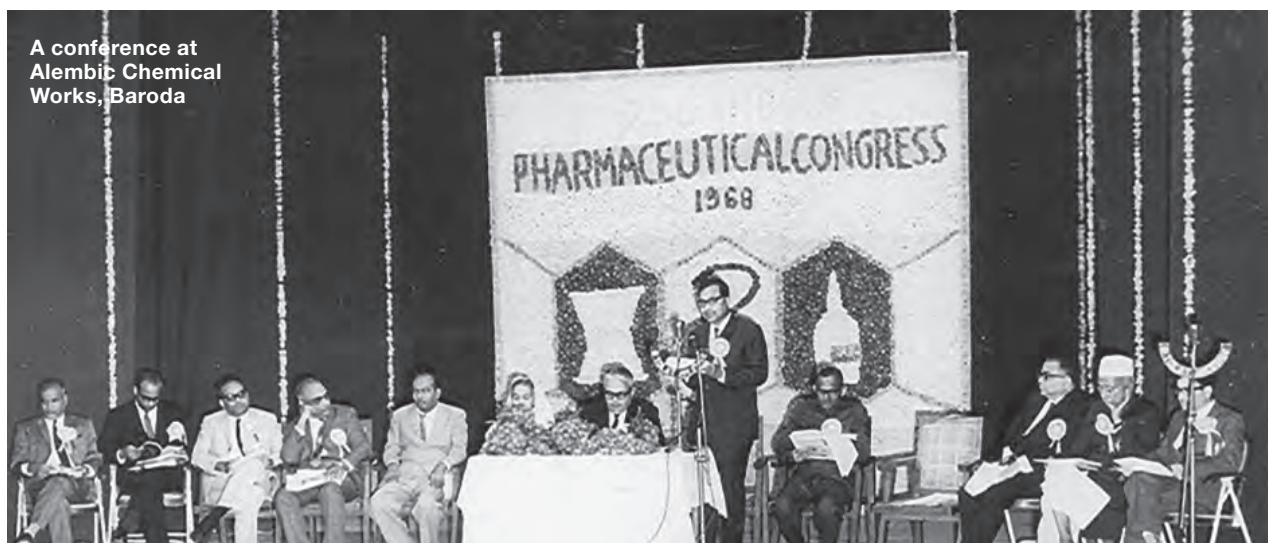


Image Courtesy: Alembicusa.com

phase could not meet the international standards. Average time scale for technology development was close to 20-40 years; the time scale in which technologies become obsolete. There were some success stories, but their export potential was questionable owing to IPR infringements. Private sector was not enthusiastic to adapt these indigenous technologies for a variety of reasons.

Globalization of the Indian economy in 1992, changed the technology scenario altogether. World had moved far ahead in technology and the idea of ‘import substitute’ became obsolete except in some strategic areas. Availability of foreign exchange in adequate quantity encouraged research institutes to import latest foreign made instruments. This essentially diluted the spirit of developing own equip-

Image Courtesy: Wikimedia Commons



Acharya Prafulla Chandra Ray, who founded the Bengal Chemicals and Pharmaceutical Works in 1892, developed it as a successful enterprise. Left: Some of its earlier products on display

become fiercer and cut-throat in respect of economic development, infrastructure, agriculture and military. The prosperity of a nation and its standing on the world stage are decided by the technologies developed by its research laboratories, both in private and public sectors. This is the challenge that we have to meet. Design, development and commercialization of such technologies will require a strong coordination between government, scientists/engineers, research institutes and industry. There are no easy fixes here, it will have to be done with a great deal of planning and hard work.

We need to appreciate the basic premises of technology development. A technology is a means to fulfil human purpose. There is no place for “Me-Too” technologies here. Technology must create an economy and jobs. As Arthur Brian says, technology relies heavily on a deep set of shared tacit knowledge, which takes time to build. We also need to avoid spreading too thin. We want to do everything at one go. Can we identify four to five strong areas to begin with and set up a time bound program with clear objectives and deliverables? Tacit knowledge will ultimately decide the success.

Finally, we need to acknowledge that disruptive technologies have come from research in universities (<https://www.onlineuniversities.com/blog/2012/08/100-important-innovations-that-came-from-university-research/>); for example, Google (Stanford University), Internet (MIT), Touch screen (Kent University), Lithium-ion battery (MIT), Wireless local area network (Hawaii University), Android (Osaka University), etc. We need to strengthen research in our universities to make them the centres of technology development.

**The writer is formerly Distinguished Scientist & Director Chemistry Group of BARC and former Senior Professor, Department of Physics, IIT Bombay.*

Image Courtesy: Shutterstock



Wootz steel originated in the middle of 1st millennium BCE in India, in present-day Tamil Nadu, and was being exported to the Arab world and Europe to make the famed Damascus swords

ment and instruments; until then it was a norm for research students to develop instruments required for their research. Indian industries did not want to reinvent the wheel but wanted to leapfrog to the current level of technology. They readily entered into foreign collaborations. Some companies developed technology platforms by outsourcing R&D across the world which gave them a way to own technology. Cash rich Indian industries acquired technology by buying high-tech international companies. Presence of foreign technology became a norm in every sphere of the economy.

WAY FORWARD

After 30 years of globalization, we have come back to square one, i.e., development of indigenous technologies. It is important to note that the word ‘indigenous’ has a very limited meaning, i.e. an import substitute. Experience of ’70s and ’80s has shown that import substitutes are of lower quality, and therefore, India needs to go beyond this narrow definition and develop original technologies which can compete globally.

The competition between the nations of the earth, which Dr Mahendra Lal Sircar described as fierce in 1890, has



Images Courtesy: CSIR-CMERI, Durgapur

SWARAJ

THE UNTOLD STORY OF INDIA'S FIRST INDIGENOUS TRACTOR

India today is the largest manufacturer of tractors in the world, but this journey began more than five decades ago in a classic case of denial of techno-financial assistance by the West



India's first and fully indigenous tractor, Swaraj (above), was born when in 1965, then USSR showed reluctance in giving technical and financial assistance for the project, and young visionaries like Man Mohan Suri and Chandra Mohan took up the challenge to create a tractor in India



■ Dr Rajesh P Barnwal

T

he adoption of technology in the Indian agriculture scenario started in the 1960s, during which mechanised farm tools, improved irrigation facilities, the use of high-yielding seed varieties, and the application of pesticides and fertilizers started getting adopted. Upon Independence, India was left with indigenous manual or animal-driven agricultural tools. The country endured two severe droughts during 1964-65 and 1965-66. But this was before the Green Revolution, which changed the agricultural scenario in the country. The Green Revolution in India was spearheaded by Dr MS Swaminathan, an Indian agricultural scientist who was conferred the honour of Bharat Ratna in February 2024. From 1968

onwards, the introduction of modern agricultural technologies in the agricultural sector improved the conditions of recurring famines in the country, and Indian farmers started to appreciate the use of technology to improve productivity and economic growth.

Alongside the Green Revolution in the country, something parallel was happening in the agricultural sector. Learning lessons from severe famines, the Indian Government started to promote mass-scale adoption of modern farm machinery and mechanically powered tools like tractors and harvesters. Animal traction started getting replaced by imported mechanically powered agriculture equipment. This is where tractors started gaining importance in the country and among the countrymen.

ROLE OF TRACTORS IN GREEN REVOLUTION

Among all the mechanised tools introduced in agricultural sector during the Green Revolution era, the tractor is the pioneer and the most prolific contributor in achieving the desired result. However, in the 1960s, India was heavily dependent on importing these tractors, which were crucial in achieving self-reliance in the agricultural sector. Most of these tractors were imported from countries like the then Soviet Union, then Czechoslovakia, Romania, Germany, the UK and Poland. In 1963-64, considering the increasing domestic demand for tractors, local industrialists started tying up with international tractor manufacturers to create joint ventures for the domestic production of tractors. This was the time when, due to the policy of the Green Revolution, the number of tractors imported in India started increasing day by day.

LANDMARK DECISION FOR INDIGENOUS TRACTOR

With the help of international tractor manufacturers, the domestic production of tractors started helping the countrymen in the mechanization of the agricultural sector, but there were still some vital concerns. Unlike the Western countries, the land holdings of most Indian



After then USSR's reluctance to assist India in its tractor project, Man Mohan Suri (top), then director of CSIR-CMERI, volunteered to design the tractor in India, and invited one of his colleagues, Chandra Mohan (above) to join him on that project

farmers were relatively small. Most of these international-brand tractors were designed for larger farmers. This forced the Planning Commission of India to rethink this matter. The Commission members began to consider the prospects of building tractors with unique designs that would fit the demands and budgets of the nation's small and medium-sized farms. There was speculation that by 1968-69, the annual demand for tractors in India would reach approximately 40,000 units. Out of these, about 50% of the tractors must be 20 HP or

below. Thus, during the Fourth Five-Year plan, developing a 20 HP tractor was recommended as one of the several crucial projects of the country. These projects were targeted to be completed with techno-financial assistance from then USSR. Thus, the Government of India decided to form a delegation to visit the USSR for further discussion.

VISIONARIES BEHIND SWARAJ

Another historical event occurred just before the decision to develop a 20 HP Tractor with USSR's technical and financial assistance. In 1964, the then Prime Minister of India, Pt Jawaharlal Nehru invited one of the very young, dynamic and visionary mechanical engineers, Man Mohan Suri, to lead the country's only national-level mechanical research institute, named the CSIR-Central Mechanical Engineering Research Institute (CSIR-CMERI), Durgapur, as its director. Man Mohan Suri was a highly acclaimed scientific personality of the time who was awarded the Padma Shri in the year 1961 and the Shanti Swarup Bhatnagar Prize (the highest Indian science award) in 1962 for his outstanding contributions to the field of Engineering Sciences. Suri was mainly known for his invention, Suri Transmission, a hydro-mechanical transmission unit for diesel locomotive engines, which finally resulted in 36 patents filed in 11 countries.

After Suri joined as the director of CSIR-CMERI, the Indian delegation, led by the then Deputy Chairman of the Planning Commission (now NITI Aayog), visited the USSR in May 1965. Suri joined the Indian delegation as a technical expert. The visit was to discuss the nature and magnitude of assistance the Soviet government could give India for developing 20 HP tractors and other projects on the list. When the Indian delegation visited Moscow to discuss the development of a 20 HP Tractor within India and sought technical and financial assistance, the Soviet counterpart showed reluctance in committing anything to the tractor project. This proved a turning point in the Indian tractor industry and India's Green Revolution.

Images courtesy: CSIR-CMERI, Durgapur

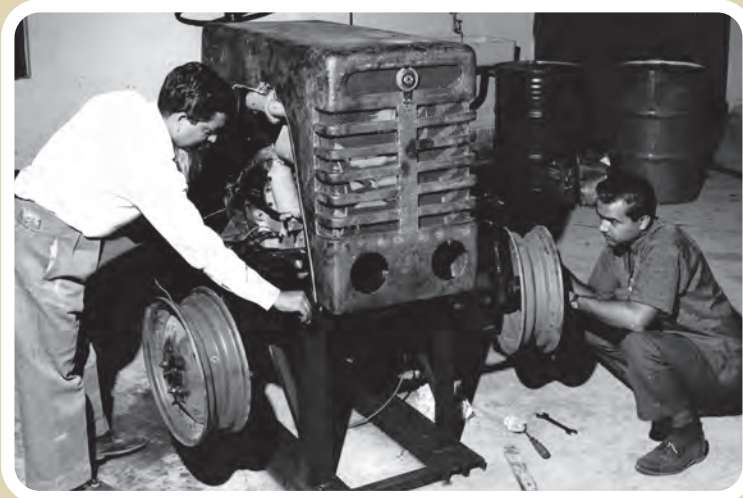
LEADERSHIP FOR TEAM SWARAJ

Triggered by the Soviet denial to extend any assistance to India to develop 20 HP indigenous tractors in the country, Suri started thinking about the pros and cons of executing such an ambitious project with the help of an international partner. He felt that the formulated project proposal was supposed to use high foreign exchange content and may also need many foreign experts on the team to design and manufacture the targeted tractor as per Indian field requirements. Since the Russians had already denied assisting the Indian team in the tractor project, Suri volunteered to design it in India. He discussed his plan with the head of the Indian delegation team. He informed the Planning Commission that CSIR-CMERI might shoulder the responsibility of designing a fully indigenous 20 HP tractor for India without seeking any international assistance. Simultaneously, he also targeted another arduous task: not to use any imported spare parts inside the targeted Indian tractor.

In the meantime, intending to form a dedicated tractor design team before visiting USSR, Suri had invited one of his colleagues, Chandra Mohan, to join CSIR-CMERI and assist him in the envisioned tractor project. Upon receiving Suri's invitation, Mohan quit his Indian Railways' service and joined CSIR-CMERI. Further, they motivated and formed a committed team of five-six fresh young engineers who could be instrumental in delivering the envisioned dream of a fully indigenous tractor in India.

THE BIRTH OF SWARAJ

CSIR-CMERI, under the leadership of Suri and Mohan, prepared a five-page project proposal for the development of a fully indigenous tractor and submitted the same in 1965 for the consideration of the Planning Commission of India. Incidentally, being satisfied with the proposal, the commission agreed to fund it. The R&D began in 1965 to design a new tractor under the direction of a specially created Committee of Technical Experts (CTE) compris-



Images courtesy: CSIR-CMERI, Durgapur



From top: Scientists working on developing the Swaraj tractor; Man Mohan Suri (front, left) at the tractor development site; the tractor being demonstrated to senior leader Morarji Desai (centre)

ing representatives from industries, agricultural universities, farmers and the Tractor Training and Testing Station (TTTS) (now Central Farm Machinery Training and Testing Institute (CFMTTI)) in Budni, Madhya Pradesh. The Indian government had originally established TTTS as the Agricultural Machinery Utilization Centre (AMUC) in 1955 at Budni with the specific objective of training future farmers about using, maintaining and up-keeping farm machinery. Later, in 1959, AMUC was renamed as TTTS after adding a dedicated testing division to assess the suitability of agricultural machines for Indian climatic conditions. Finally, in 1983, the TTTS was again renamed to CFMTTI after being upgraded significantly with a specific focus on testing and training of farm machinery and equipment.

The core design team, under Suri and Mohan's mentorship, started its endeavour with minimal knowledge about the agricultural tractors and prevailing constraints in terms of resources available to them. To understand the technical insights of the required specifications of an agricultural tractor, several patents were studied, and consultations were made with different Indian agricultural universities and even with individual farmers of the country. Considering the Indian weather conditions and to achieve a cost-effective design, the modular design strategy was adopted. The relative merits of the available design of agricultural tractors were studied in depth. Furthermore, due to possible manufacturing facilities, current skills, available raw materials, local agricultural practices, and weather conditions, a custom design of an indigenised tractor started taking shape by developing each of its components. In the process of R&D developing indigenised parts,

Finally, in November 1967, the prototype of a fully indigenised, custom-made tractor saw the light of the day

it had been felt that the availability of standard hydraulics was critical for a good agricultural tractor. This inspired the team of CSIR-CMERI to develop a single-lever automatic depth-cum-control hydraulic system and original power transmission system for the indigenised tractor. Development of such crucial tractor components resulted in the acceptance of patents simultaneously in India, USA, UK, Germany, Japan, France, Poland and Yugoslavia, which became a landmark in achieving the indigenised technologies for the development of tractors.

Finally, in November 1967, the prototype of a fully indigenised, custom-made tractor saw the light of the day. Specially designed test rigs were created to test the prototype extensively in simulated field conditions, and such tests lasted non-stop for over 1,200 hours



with 10-30 per cent overload during the hottest summer months. Two years after testing the prototype, three more units were developed and assembled in March 1969 for extensive field trials and performance evaluation at the TTTS, Budni. The tractor was again set for testing in May/ June 1971 after incorporating several modifications in the hydraulics, steering gear, front axle, engine and cooling system. Interestingly, this first Indian tractor from CSIR-CMERI surpassed all the expectations of its developers and performed better than most of the imported tractors in the power range of 20-25 HP, primarily in terms of drawbar pull and drawbar HP to available PTO power ratio, which are the prime requirements for any agricultural tractors.

The time had arrived to name this India's first tractor, and it was thought that the given name should be easy to pronounce and signify the power and grace of the in-



The CSIR-CMERI campus, Durgapur

digenously developed product. Finally, the name ‘Swaraj’ was suggested and approved by then Prime Minister of India, Indira Gandhi. The name ‘Swaraj’ draws inspiration from Mahatma Gandhi’s ‘Swaraj’ concept, which signifies economic freedom and self-reliance.

SWARAJ’S STRUGGLE TO GET FINANCIALLY ESTABLISHED

As a new technological baby of India, Swaraj was now looking for a good commercialisation partner who could take this excellent product to the market to make the country ‘Atma Nirbhar’ in terms of a Swadeshi tractor. The earlier prototype was fabricated with the financial assistance of a Durgapur-based public sector, namely Mining and Allied Machinery Corporation (MAMC). However, during the economic recession of 1967-71, the MAMC withdrew its support due to business losses. At that time, the Punjab State Industrial Development Corporation Limited (PSIDC), impressed by the indigenous design of Swaraj, its acceptability among the farmers of the Punjab and future employment potential in the state, extended its hands for production. In 1970, PSIDC approached CSIR-CMERI and

obtained the technology license to manufacture the Swaraj tractors. Later, the PSIDC requested CSIR-CMERI authority to release those five engineers who worked on the Swaraj project to join their newly established firm, Punjab Tractors Limited (PTL), Mohali. After getting relieved from CSIR-CMERI, Chandra Mohan joined PTL as its MD. Suri established M/s Suri & Associates, which later worked as a consulting firm to prepare a detailed project report (DPR) to help PTL with the tractor manufacturing project. For financing the project, PTL approached the Industrial Development Bank of India (IDBI), but they faced denial as PTL was able to contribute less than 10% of the total project cost, contrary to the requirement of 15-20%. However, considering the excellent DPR and commitment of the project promoters, IDBI’s top management agreed to approve the financial assistance of more than 85% of the total project cost.

TRANSFORMING INDIA AS A TRACTOR EXPORTER

The nation has been on a long journey since the launch of the first Swaraj tractor. Swaraj Tractors achieved a historic

milestone by creating India’s first indigenous tractor. PTL first commercially launched Swaraj 724 in 1974. As a result of the initiation of endeavour for Swaraj, India transformed from an importer of tractors to the world’s leading exporter of tractors. Swaraj 735 was awarded with the National Gold Shield Import Substitution during 1975. Chandra Mohan was awarded with Padma Shri in 1985 for his rare entrepreneurial acumen and business strategies. He has lately come to be regarded as the ‘Father of Tractor’ in India. In the early 2000s, India surpassed the United States as the world’s leading manufacturer of tractors. In 2007, Mahindra & Mahindra Ltd. bought a majority share in PTL, which was incorporated into M&M as the Swaraj Division in February 2009. In 2013, India produced 6,19,000 tractors, accounting for 29% of the global output. In 2018-19, Swaraj produced over 1,20,000 tractors, the second highest by an Indian tractor brand during the year and has sold over 1.5 million tractors since inception. Despite economic liberalisation in 1991, during the 50th year of Swaraj, M&M leads tractor industries in India with a total of 41.68% market share in FY 2023-24.

The story of Swaraj, the tractor, is inspirational in its own right but also holds deeper significance in an age and time when there is all round emphasis on Atma Nirbhar Bharat by developing indigenous technology for the country’s progress, and especially relevant in this month when India celebrates National Technology Day in honour of another indigenously developed technology—the nuclear technology.

**The writer is the Principal Scientist and Head of Information Technology at CSIR-Central Mechanical Engineering Research Institute, Durgapur. He is an alumnus of IIT Kharagpur and also associated with the Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, as an Associate Professor of Engineering Sciences. He can be reached at r_barnwal@cmeri.res.in.*



SCIENCE DIPLOMACY

India's Technological Rise: A Diplomatic Game Changer

As India transitions from an agrarian to a tech-driven economy, not only does its status get elevated globally, it also acquires unprecedented diplomatic heft



■ Uday Kumar Varma

In a recent editorial dated 18 April 2024, *Nature*, deemed by common consensus, the world's most respected science journal, alludes to India's potential ascent as a science and technology powerhouse. This acknowledgment not only reflects India's recent advancements but also hints at the vast possibilities awaiting realization. Describing India as one of the world's most prolific countries in terms of research output, *Nature* underscores the nation's readiness to step into the role of a science powerhouse.

'This is not yet a given, but it can happen', it says. Characteristically putative and linking the future to the outcome of the ongoing election, this appraisal must be viewed both as an honest assessment and a cautious forecast.

RECENT STRIDES IN SCIENCE AND TECHNOLOGY

India has been making significant strides in various sectors, showcasing its emergence as a global power. For instance, in 2021–22, India ranked third globally in pharmaceutical production by volume, a testament to its leadership in providing affordable medicines and generic drugs, especially crucial during the COVID-19 pandemic. It produced more than 2.2 billion doses of Covid vaccine for domestic use and also helped over a score of countries. Moreover, India achieved a historic soft Moon landing, becoming the fourth country to do so and the

first near the lunar south pole. Its satellite technology also boasts the world's largest constellation of remote-sensing satellites.

India's prowess in research is evident, trailing only behind the United States and China in terms of research output among countries. Over the past decade, the nation has witnessed a significant increase in educational and research institutions, including universities and Indian Institutes of Technology and Science Education and Research. Notably, these achievements were accomplished with a relatively low investment in research and development (R&D) compared to other high-income countries.

Concurrently, India has been stepping up her expenditure on R&D. The GERD (Gross Expenditure of R&D) more than doubled between 2010–11 (Rs 60,196 crore) and 20–21 (Rs

Image Courtesy: Shutterstock

127,380 crore) with per capita spending (PPP) rising from \$29 in 2007-08 to \$42 in 2020-21.

STRATEGIC FOCUS ON INDIGENOUS INNOVATION

India's strategic focus on self-reliance and indigenous innovation has been a driving force behind its domestic growth and global positioning. The nation is now poised to leverage its scientific and technological advancements across critical sectors such as pharmaceuticals, medical equipment, space technology, tele-communication, defence production, semiconductors, and renewable energy.

Expanding satellite services, investing in advanced propulsion technologies, and fostering start-ups can propel India into a more significant role in the commercial space market. Likewise, India's successful campaign in getting 5Gi (Rural Broadband requirement) included in the global 5G, gets her a place in the World Telecom Standards Community, creating a wedge for licensing agreements of 5G technologies.

In the defence sector, initiatives like 'Make in India' are promoting indigenous manufacturing and innovation, particularly in areas like artificial intelligence, unmanned aerial vehicles, and cybersecurity. The recent sale of missiles to the Philippines points to capabilities, once considered out of reckoning.

India's semiconductor industry, aiming to address the global shortage, requires substantial investments in infrastructure, skilled labour, and R&D to become a leader in this critical sector.

Renewable energy technologies also hold immense potential for India, aligning with its commitments to sustainability and global leadership in areas like solar panels, wind turbines, and energy storage solutions.

HARNESSING INTELLECTUAL PROPERTY RIGHTS

Intellectual Property Rights (IPR) and patent registration are crucial for fostering innovation and attracting foreign investment, enhancing the global competitiveness of India's key industries like

pharmaceuticals, biotechnology, semiconductors, and information technology. Effective IPR protection motivates inventors and reassures international businesses on the safety of their intellectual property.

India has made strides in strengthening its IPR framework to align with international standards, including reforms to comply with the World Trade Organization's TRIPS agreement. Despite a notable increase to over 34,000 patent applications in 2021 as reported by the World Intellectual Property Organization (WIPO), India still trails behind global leaders like the United States and China, particularly in patent processing and litigation infrastructure. With China accounting for half of the roughly 3 million patents filed globally last year, the urgency for India to elevate its IPR strategies and execution is evident.

The National Intellectual Property Rights Policy and the creation of the Cell for IPR Promotion and Management (CIPAM) are significant steps toward enhancing IPR awareness among start-ups and SMEs. However, much work remains, especially in streamlining patent processes and improving awareness and utilization of IPR among businesses.

To catch up with global leaders, India must focus on modernizing patent processes, increasing professional training, and expanding access to resources for IPR litigation. Enhancing these areas will secure India's intellectual property environment and support a thriving eco-

system of innovation and investment.

INNOVATION & START-UP ECOSYSTEM – KEY TO SELF-RELIANCE

In the contemporary industrial vocabulary, the term 'Jugaad' stands out as a quintessentially Indian contribution. Representing a form of innovation that maximizes resourcefulness through lateral thinking and ingenuity, Jugaad is emblematic of the resilience and inventiveness inherent in Indian entrepreneurship and a fundamental trait and asset.

India has consistently improved its global innovation ranking. It has maintained its 40th rank among 132 economies in the Global Innovation Index 2023, as published by the World Intellectual Property Organization, ascending impressively from its 81st position in 2015.

As of 2023, India boasts over 112,718 government-recognized start-ups, a significant rise from around 50,000 in 2018. This surge highlights India as the third-largest start-up ecosystem globally, with over 100 among them qualifying as unicorns with a valuation of nearly \$350 bn, with the distinct possibility of some of them becoming decacorns soon. These start-ups are spread across 763 districts in the country, clearly underlining this spatial significance.

ANUSANDHAN – NATIONAL RESEARCH FOUNDATION

'The world's most populous democracy and the fifth-largest economy has an opportunity to reimagine its science funding', pleads *Nature*. It argues for greater participation of the private sector in India's research spending and refers to the recent initiative of setting up a National Research Foundation.

The Anusandhan National Research Foundation (ANRF) has been established by an Act of Parliament, subsuming the erstwhile Science and Engineering Research Board (SERB) established by an Act of 2008. The ANRF aims to seed, grow, and promote research and development (R&D) and foster a culture of research and innovation throughout India's universities, colleges, research in-

With China accounting for half of the roughly 3 million patents filed globally last year, the urgency for India to elevate its IPR strategies and execution is evident

stitutions, and laboratories. ANRF will act as an apex body to provide high-level strategic direction of scientific research in the country as per recommendations of the National Education Policy (NEP). ANRF will forge collaborations among the industry, academia, and government departments and research institutions, and create an interface mechanism for participation and contribution of industries and state governments in addition to the scientific and line ministries.

NRF budget envisions a spending of Rs 50,000 crores over five years, out of which a major share of Rs 36,000 crores, over 70%, is estimated to come from non-government sources, from industry and philanthropists, from domestic as well as outside sources.

“NRF will catapult us to the league of handful developed nations pioneering new research in new frontiers,” says Dr Jitendra Singh, the Union Minister of State for Science and Technology.

The establishment of ANRF marks a significant milestone in India’s research and innovation ecosystem. By catalysing collaboration among industry, academia, and government institutions, ANRF is poised to accelerate India’s scientific advancements and technological breakthroughs. The substantial budget allocation, with a focus on non-governmental sources, reflects a paradigm shift towards a more robust and sustainable research framework.

INDIA’S DIPLOMATIC INFLUENCE THROUGH TECHNOLOGY

India’s transformation into a technological hub not only elevates its global status but also enhances its diplomatic reach. As it transitions from an agrarian to a tech-driven economy, India provides a successful model for other developing nations, demonstrating pathways to technological and economic independence.

STRENGTHENING TIES IN THE GLOBAL SOUTH

India’s technological advancements allow it to lead in various domains such as climate change, healthcare, and digital infrastructure, leveraging these



Image Courtesy: ISRO

India has been marching stridently in various sectors of science and technology, such as becoming the first country to reach the lunar south pole in August 2023

strengths to foster deeper connections within the Global South. Some of the key strategies may include:

Developmental Models: India’s shift towards self-reliance and indigenous innovation offers a blueprint for similar advancements in the Global South, encouraging economic sovereignty without heavy reliance on Western technology.

Capacity Building: Through partnerships, India shares its expertise in IT, renewable energy, and pharmaceuticals, reinforcing its role as a leader while aiding development in partner countries.

Trade and Industry: Developing its high-tech industries allows India to provide cost-effective alternatives to Western and Chinese products, diversifying trade options and strengthening economic ties in the region.

Strategic Partnerships: Technological prowess in areas like space technology facilitates collaboration on projects like satellite launches, enhancing India’s diplomatic leverage.

Climate Leadership: Leading in renewable energy, particularly through initiatives like the International Solar Alliance, India supports other nations’ sustainability efforts and asserts itself as a global environmental leader.

Healthcare Diplomacy: India’s role as a major pharmaceutical provider during the COVID-19 pandemic exemplifies its potential to influence global health diplomacy and support the Global South during health crises.

Digital Innovation: By advancing digital infrastructure and cybersecurity, India offers models for digital governance that can transform educational and business practices in the Global South.

Global Advocacy: Technological and economic progress equips India to advocate more effectively for fair trade and equitable growth on platforms like the United Nations and the World Trade Organization.

India’s odyssey in science and technology heralds a new era of diplomatic clout and international leadership, driven by innovation, collaboration, and a commitment to sustainable development

This ascent provides her with substantial leverage to shape global dynamics, particularly in the Global South. This leadership, derived from advancements in technology and science, not only enhances India’s international stature but also contributes to a more balanced and multipolar world order, where the interests of developing nations are more prominently represented and respected.

**The writer, a Harvard educated civil servant, is a former Secretary to the Government of India. He also served on the Central Administrative Tribunal and as Secretary General of ASSOCHAM. He commands extensive expertise in the fields including Media and Information, Industrial and Labour Reforms, and Public Policy.*



We make the best, even better.

JSW - A conglomerate
worth \$23 Billion believes in
transformation to make
a better world every day

It takes a strong will to be ranked among India's top business houses. But it was stronger dreams and ambition that made us venture into the core sectors of Steel, Energy, Cement and Infrastructure. Our strength, state-of-the art technology and excellence in execution have helped us grow and that has helped India grow multi-fold. By harbouring dreams of transformation, focusing on sustainability and a philosophy; to give back to the country, the JSW Group is making a better world every day.

Steel | Energy | Infrastructure | Cement | Paints
Realty | Ventures | Foundation | Sports

www.jsw.in | [@TheJSWGroup](https://twitter.com/TheJSWGroup)

JSW
Better Everyday

Hydroscience in Indian Tradition

Water, one of the *panchamahabhutas* that is absolutely essential for life on earth, was studied in detail by ancient Indian seers, whose research can benefit modern forays into the subject



The origin of 'Hydrology' in the Indian tradition is 5000 years old, whereas modern Hydrology developed in the 19th century and is still in the stage of development. In the scriptures of *Rigveda*, *Yajurveda* and *Atharvaveda* composed in the Vedic period, there are many verses, *sutras* and praises regarding the types of water, ground water and quality of water. Hydrological cycle is also described scientifically in *Rigveda*.

Jal or water has also been described in detail in our traditional scriptures, *Puranas* and *Sambitas* written after the Vedic period. In chapter 54 of *Vrihatsambita* written by Varaha Mihir, a disciple of Aryabhata Pratham in the 5th century, complete hydrology is mentioned in 125 *sutras*. Based on the characteristics described in *Vrihatsambita*, it was possible to discover groundwater reserves up to a depth of 600 meters. Even before Varaha Mihir, there were Saraswat and Manu who wrote on



■ Dr Sunil Chaturvedi

water in their scriptures. Varaha Mihir himself has mentioned them in his texts. Sushruta, the author of Ayurveda text *Susbruta Sambita* (circa 6th century BCE) and Charak, who wrote *Charak Sambita* (circa 2nd century BCE) have also described water, its quality and its effect on health.

Even the scientists who consider modern European science as original science are shocked by this scientificity inherent in the Indian tradition of thousands of years ago. Modern hydrology can be enriched by scientists doing research on hydrology described in Indian tradition.

HOW COLONIAL RULE RUBBISHED INDIAN SCIENCE

There is an old Indian saying: *Ghar Ka Jogi Jogda, Aan Gaon Ka Siddh*, which implies that a homegrown Yogi has no value compared to a novice from another village. During the 190 years of colonial rule, the British were successful in implanting in the minds of the Indian people that all their scriptures — *Vedas*, *Puranas*, *Upanishads*, *Sambitas* — written in the Indian Rishi tradition were orthodox, imaginary and unscientific. Only the science that came from the West was authentic science. Pushing aside our Vedas, scriptures, codes, culture and traditions, we not only accepted external science as the real science but also became its advocates. We started criticising our own tradition, knowledge and culture.

Was it really the knowledge that came from our traditions that was unscientific and only the science of Europe authentic?

I am a student of hydrogeology and



Gurudongmar lake, located in Sikkim, is considered sacred by both the Buddhists and Sikhs. It is the one of the highest lakes in the world and in India, at an elevation of 5,430 m (17,800 ft)

I will talk about this science in this context. I have no hesitation in admitting that during my student life, I also had the same belief that only the vision coming from the West was scientific.

But when my understanding matured a bit and I came in contact with some ideological people, I started exploring hydrology in Indian tradition.

WATER IN ANCIENT TEXTS

By reading the verses, *sutras* and hymns mentioned in the Vedas, it became clear that whatever was written related to water and ground water in the Vedic period was scientific. Verse 13.53 of *Yajurveda* talks about the water cycle. Due to the heat of the sun, water breaks and rises. The wind blows away these water droplets and transforms them into clouds and this water again reaches the earth in the form of rain. I was surprised! In modern science, Leonardo da Vinci discovered the Hydrological Cycle in the 14-15th century, that is, only 800 years ago, whereas in the Indian tradition, our sages had explained it during the Vedic period itself.

Similarly, in verse 27.25 of *Yajurveda*, it is said that the seed of creation was first sown in water and from it fire originated. In modern science, this thing has been clarified in this way — in the

initial times on the Earth, oxygen was bound in abundant molecules like water and carbon dioxide. About a billion years ago, blue-green algae and cyanobacteria used sunlight to break water into its components oxygen and hydrogen and thus free oxygen came into the atmosphere. This free oxygen was the pulse of life on the Earth. Here, one can raise the question on the scientificity of this verse of *Yajurveda*. Actually, the Indian tradition was of Gurukul where the knowledge in the *sutra* was explained by an Acharya and not through a textbook written in detail.

There is a description of four types of water in *Rigveda*: 1. Water obtained from the sky, 2. Water flowing in rivers and other streams, 3. Water obtained by mining from wells, and 4. Ground water. The Vedas even describe the kind of water that will flow in a particular geographical location. In this regard, the *Atharvaveda* mentions that the water coming from the Himalayas breaks after hitting the rocks and becomes smaller due to bouncing and flowing with speed. Therefore, this water is beneficial for all living beings. The rivers going to the western sea flow fast, hence their water is also clean and beneficial. The rivers going towards the eastern sea flow slowly, hence their water is heavy.

Sea water is full of Tridosha and salt and hence is not suitable for drinking.

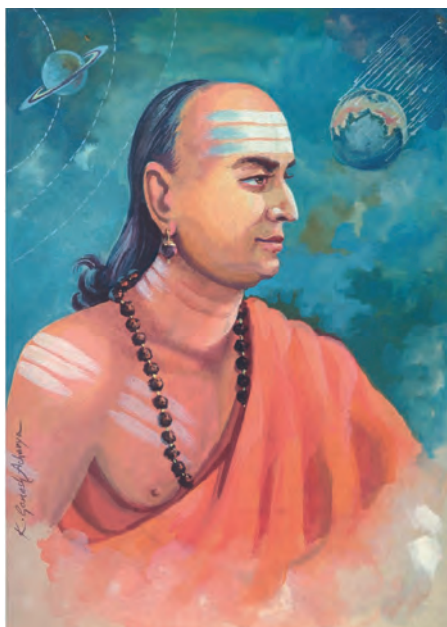
Just imagine the time when all this was explained in the Indian tradition — three-thousand-five-hundred years ago! Even after knowing all this, calling Indian traditions, Vedas and scriptures unscientific, and modern science as science would be like making one's own line bigger by erasing the big line. Western science is doing the same and it's time we understood that our Indian tradition was more advanced and scientific.

Even post-Vedic texts of our sages continue to mention water in detail. In this series, the *Vrihatsambhita* written by Varaha Mihir has revealed many mysteries along with astrology by giving scientific explanations of weather, earth, space and activities taking place below the surface. In the chapter 'Drikargal' of *Vrihatsambhita*, 125 *sutras* related to prediction of ground water on the basis of local vegetation, soil, animals and rocks have been given, on the basis of which the ground water found up to a depth of 600 meters can be predicted. According to Varaha Mihir, just as there are thousands of nerves in our body, similarly there are many veins in the earth at different heights and at different depths. Rainwater seeps into the ground and flows as groundwater in these veins at different depths. Modern science also believes that the flow of groundwater from one place to another occurs due to the underground gradient of the water table. Except in the Sand Zone, in rocky areas the flow of groundwater at depth is less at some places and more at others.

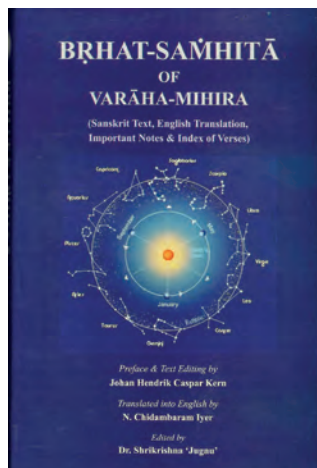
In verse 2 of 'Drikargal' of *Vrihatsambhita*, Varaha Mihir writes that the water that rains from the sky is of the same colour, but due to the difference in the soil, vegetation and rocks of the area with different geographical conditions and climate, the difference in the quality of water arises.

PROSPECTING GROUNDWATER

According to modern science also, due to contact with soil and vegetation in different areas, the quality of water changes according to the mineral salts



Images Courtesy: Internet



Varaha Mihir wrote *Brihat Samhita* (also spelled as *Vrihatsambhita*) in 6th century CE, which presages many modern theories of hydrology

present in the soil and vegetation. Similarly, passing through different types of geological strata under the ground, due to the different mineral constitution of different types of rocks, many mineral salts dissolve and change the quality of water. For example, the quality of water passing through the Limestone area will be different from the quality of water passing through Sandstone and Basaltic Rock. Based on this, Varaha Mihir's hydrology is even able to predict the taste of water found in a particular area — salty, sweet, astringent or bitter. Even if it will be drinkable or not.

Varah Mihir writes in Sutra 104 of Vrihatsamhita that the groundwater found below the land will be gritty (with small pebbles) and copper coloured. The groundwater found in the area where the soil is of ash colour will be alkaline. The water in the area with light coloured soil will be salty and the water in the area with light black and greyish coloured soil will be sweet. This formula of Varaha Mihir, dating to about 1900 years ago, proves to be authentic. There is no need for any big scientific instruments or study for this, it can be experienced only by drinking the water of a particular area. I have experienced this many times during my work and have found it completely authentic.

Varaha's hydrology does not stop at this, it also predicts the available amount of groundwater — will water be available for years or will it run out in a few months or years? In verse 109 of 'Drikargal', Varaha Mihir writes that water is not found under rocks that are copper coloured or light yellow, ash coloured or light brown or bright blue.

Varah Mihir has suggested several methods to detect groundwater based on the vegetation of a particular area.

See verse 8 of 'Drikargal'. In this verse, Varaha says that if a Jamun tree is seen in an anhydrous area, then by digging 'Do Purush' (about 10 feet) three cubits ahead of it in the north direction, water will be found in the vein to the east. Geological strata have also been mentioned in this verse. If a man digs 5 feet, he will find Ferruginous

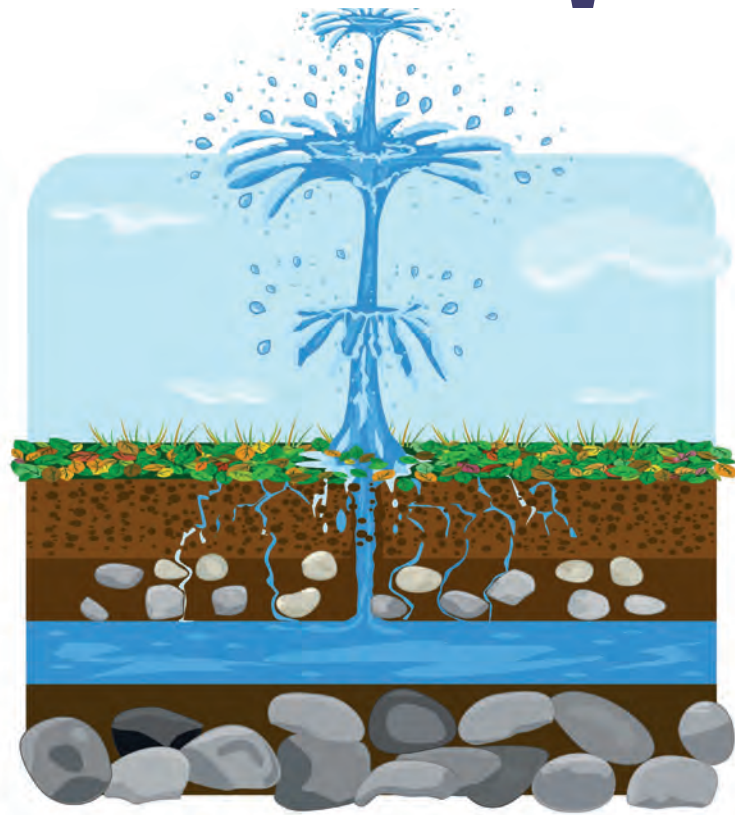


Image Courtesy: Shutterstock

According to modern science, water quality is affected by its movement through various geological strata under the surface of the earth, a proposition that was delineated by Varaha Mihir approx. 1900 years ago

Soil, after that Light Yellow Soil will be found and then a frog will be found. It is said in verse 13 that if there is an earthen stupa made by insects towards the north from the Terminalia Arjuna (Arjuna) tree, then water will be found three and a half feet below the Arjuna tree in the west direction. If a man digs at this place, he will find dust coloured soil, below that will be black soil, below that will be yellow soil and after that sand mixed white soil. There will be immense water beneath it.

In verse 58, the two-faced date palm (*Phoenix sylvestris*) tree has been described as a vegetative guide for the availability of groundwater. While working as a Hydrogeologist in Rajgarh district of Madhya Pradesh, I dug tube wells at many places on this basis and found sufficient ground water in all of them.

Even in modern hydrology, there is mention of vegetative guides to detect groundwater. Modern botanical science also believes that there are some

trees which indicate the availability or unavailability of water beneath them. Soil Science also says that there is normal water beneath yellow, grey, sandy and red soil. Similarly, in areas with dry and semi-arid climate, many chemical changes occur in the rocks due to the moisture present inside the ground, on the basis of which prediction of groundwater is possible.

Along with the prediction of groundwater, Varaha Mihir has also propounded the methods of water quality, well and pond construction in his scriptures which are relevant even today.

I have a lot to say about water in our Indian tradition but that goes beyond the scope of this write-up. I would like to sum up that modern hydrology can be enriched by making Varaha Mihir's hydrology the basis of research.

**The writer is a Hydrologist and has been working in Madhya Pradesh on water conservation with Vibhavari, a social organization, for the last 35 years.*

SCIENCE BEHIND TEMPLES

Scientific Evolution of Acoustics and Optics in Indian Temples

A Hindu temple carefully utilises the power of sound and light to heighten and elevate the experience of worshipping a deity



Sun Temple in
Modhera, Gujarat



■ Dr Punit Kumar

Within the sacred confines of temples, amidst the fragrance of incense and the murmurs of devotees, lie profound secrets waiting to be unearthed. These ancient sanctuaries, steeped in spirituality and adorned with architectural splendour, serve as repositories of scientific marvels that have captivated scholars and worshippers for centuries.

Acoustics, the science of sound, and lightning, the powerful force of nature, both find resonance within the hallowed halls of temples. Through a blend of ancient wisdom and astute engineering, these sacred spaces are transformed into theatres of sensory wonder, where the celestial harmonies of light and sound converge to elevate the spiritual experience of worshippers.

The science of acoustics reveals itself in the intricate architectural design of temples, where every column, chamber, and sculptural element is meticulously crafted to manipulate sound waves with precision. From the whispering galleries of ancient temples to the resonant chambers of majestic sanctuaries, these architectural marvels amplify chants and prayers, creating an immersive auditory experience that transcends the mundane and transports worshippers into a realm of divine resonance. Simultaneously, the phenomenon of lightning adds an element of awe and reverence to the temple landscape, as towering spires and ornate *gopurams* reach skyward to commune with the heavens.

**TEMPLE ACOUSTICS:
AN EVOLUTION OF CENTURIES**

The acoustics of Hindu temples are not merely accidental, but the result of deliberate architectural design and construc-

tion techniques refined over centuries. One of the key elements is the strategic placement of structural elements such as columns, chambers, and sculptural reliefs which serve to manipulate sound waves, enhancing resonance, amplification, and clarity within the temple space. For example, the layout of the temple corridors and halls is often designed to create natural echo chambers, where sound waves bounce off the walls and ceilings, creating a prolonged reverberation.

Further, the sculptural adornments adorning the temple walls play a crucial role in shaping acoustics. Intricately carved reliefs act as acoustic diffusers, scattering sound waves and reducing distortion, while also adding to the visual splendour of the temple environment.

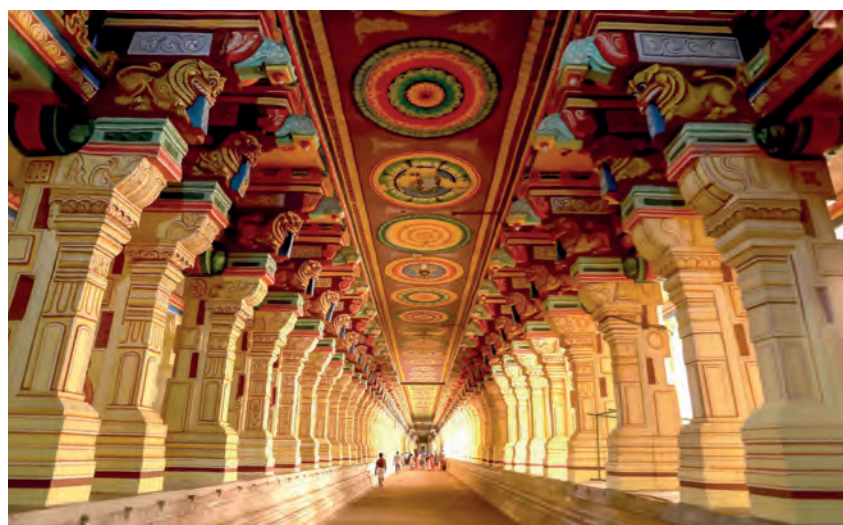
The most crucial area within a Hindu temple is the Garbha Griha, also known as the sanctum sanctorum. This chamber's dimensions are meticulously determined based on the size of the deity it houses. It features only a door, devoid of windows, and only the designated priest is permitted entry for worship and rituals involving chants and prayers. During worship, the priest often accompanies the chants with the ringing of a hand bell. Typically constructed with stone walls, the Garbha Griha possesses intriguing acoustic properties, it exhibits high reflectivity and a prolonged

reverberation time. Moreover, this chamber usually connects to another area through its entrance, known as the Ardha Mantapa. Like its counterpart, the Ardha Mantapa boasts reflective surfaces and a significant reverberation time. The Ardha-Mantapa serves as a vital space where multiple priests chant in unison, accompanied by the sounds of instruments like conch shells, bells, and gongs. Typically, the Ardha Mantapa leads into the Maha Mantapa or main hall, where a large congregation of devotees gathers to participate in worship ceremonies.

The reverberant qualities of temple spaces create an immersive atmosphere that envelops worshippers in sound, fostering a sense of presence and connection to the divine. As chants, prayers, and hymns resonate within the temple chambers, devotees feel transported into a sacred realm where they can commune with the divine presence. The reflective and reverberant qualities of temple acoustics create an environment conducive to meditation and contemplation.

**BELL AND CONCH:
HEIGHTENING THE SENSES**

In Hindu philosophy, sound holds a fundamental role in creation, with the divine syllable 'Om' embodying the essence of the universe. A finely crafted bell is a crucial element in most Hindu



Sound waves echo exceptionally well at Sri Ramanathaswamy Temple in Rameswaram, Tamil Nadu, built between 11th-12th and 17th centuries

Image Courtesy: Sonam Singh Subhedar

Image Courtesy: Wikimedia Commons

rituals and prayers, serving as an integral part of worship ceremonies. Interestingly, a bell often produces prolonged strains of the sacred sound 'Om'. The sound emitted by a well-crafted bell is characterised by its uninterrupted, resonant, and deep quality. Bells utilized in temples are commonly fashioned from a combination of five metal alloys known as *panchaloha*, including gold, silver, copper, iron, and lead. The proportion in which each metal is mixed to create a temple bell is the science behind it. Each of these metals is mixed in such a way that when the bell is rung, it produces a distinct sound that creates unity of your left and right brain. As a result, the bell emits a clear and enduring sound that resonates for approximately seven seconds. This sound reverberates through the body, reaching the seven energy centers, or *chakras*, promoting a sense of alignment and balance. Upon hearing the bell, the mind briefly enters a state of trance, characterized by heightened receptivity and awareness.

These bells come in two primary forms, hanging bells and hand bells. Notably, studies have shown that the fundamental and second higher tones of hanging bells align with the spectra of hand bells. However, the measured sound pressure level of handbells is high-



At the 7th century Arasavalli Sun Temple in Andhra Pradesh, the sun's rays fall at the feet of the deity on summer solstice and winter solstice

Image Courtesy: Quora

er than that of hanging bells. This difference can be attributed to the pendulum striking at two points in a very brief time span, compared to hanging bells.

The conch shell, scientifically known

as *Turbinella Pyrum* or Indian Conch (Shankh), serves as a musical wind instrument crafted from the large shell of certain sea snails. In Hindu tradition, it holds profound significance, symbolising qualities like brilliance, purity, and auspicious beginnings. Often utilized in temple rituals, the conch shell's resonant tones mark the commencement and conclusion of worship ceremonies, as well as the arrival of revered deities. It functions both as a musical device and a vessel for sacred water, believed to possess the power to dispel malevolent spirits. Notably, its distinctive sound carries a loud and penetrating quality, easily recognizable to listeners.

To enable the conch shell's use as an instrument, the pointed tip at its closed end is typically removed, opening up the cavity. Players produce sound by blowing into this opening while vibrating their lips. When the frequency of these lip vibrations aligns with the resonance frequency of the shell's cavity, a distinct tone emerges. Skilled musicians can manipulate the pitch by adjusting lip tension and blowing intensity, akin to techniques employed with brass wind instruments.

Ancient Indian temple architecture skilfully incorporates acoustic principles to enrich the auditory aspect of rituals and ceremonies. Here are a few instances showcasing the remarkable acoustics found in ancient Indian temples:

Brihadeeswarar Temple, Thanjavur: The temple boasts remarkable echo effects, allowing even the faintest sounds to travel clearly from one end to the other without distortion.

Meenakshi Amman Temple, Madurai: The musical pillars produce distinct musical notes when struck, resembling various instruments like drums, tabla, and flute.

Sri Ramanathaswamy Temple, Rameswaram: The shrine resonates sound waves with exceptional clarity, enhancing the auditory experience during rituals and ceremonies.

Chennakeshava Temple, Belur: The temple's hall features pillars that emit distinct musical tones when struck, adding to the temple's acoustic allure.

Jagannath Temple, Puri: This temple



Image Courtesy: Wikimedia Commons

Pillars at the 12th century Chennakeshava temple of Belur in Hassan district of Karnataka emit distinct musical tones

possesses unique acoustic properties. When someone whispers into one corner, the sound is transmitted and echoed throughout the entire structure.

SIGNIFICANCE OF OPTICAL ELEMENTS

Within Hindu temples, lightning carries diverse symbolic meanings that are subject to contextual and interpretive nuances within Hinduism. Frequently, it is perceived as a tangible representation of divine potency or vitality. In Hindu iconography, deities are commonly depicted wielding symbols of authority, which are closely linked to the concept of lightning. The luminosity and vigour inherent in lightning are sometimes associated with processes of purification and sanctification. Nevertheless, the interpretation of lightning's significance in Hindu temples can vary significantly based on cultural, religious, and individual perspectives.

The Garbha Griha is often deliberately enveloped in profound darkness. As worshippers advance towards this central sanctuary, they embark on a ceremonial progression through gradually dimming spaces within the temple. This journey, both spiritually and physiologically significant, allows pilgrims to acclimate themselves to the darkness, fostering a mindset conducive to worship and liberating them from worldly diversions.

Techniques such as casting mysterious shadows by reflecting light off walls, allowing subdued light to filter through openings, and utilizing light as a focal point were among the methods employed to harness natural light's symbolic significance as a conduit to the divine. Consequently, natural light emerged as a pivotal element of religious symbolism in sacred architecture.

Oil lamps hold a profound significance beyond mere illumination. Within the *diya* lies a deeper symbolism, the oil represents the impurities that dwell within the human mind, such as greed, jealousy, hatred, and lust that individuals often harbour. Conversely, the cotton wick symbolizes the *atma*, the self, or the soul. As the oil is consumed by the flame, it generates light, signifying



Image Courtesy: Ram Janmabhoomi Teerth Kshetra Trust

A 75-mm Surya Tilak appeared on the forehead of the idol of Lord Ram for six minutes at noon on April 17 this year at Ram Mandir in Ayodhya

the need to dispel selfish and materialistic thoughts. This act of lighting the *diya* serves as a metaphorical journey towards liberation from all forms of sorrow, paving the way for enlightenment and establishing a connection with the Supreme Being.

Here are some remarkable examples of optical marvels:

Konark Sun Temple: The first rays of the Sun fall on the temple's main entrance. Its iconic wheel, the most popular image of the temple, also works as a sundial.

Brihadeeswarar Temple: Notably, the temple's towering *vimana* boasts a design feature ensuring that it never casts a shadow at noon, regardless of the time of year.

Arasavalli Temple: At Arasavalli, close to Srikakulam, in Andhra Pradesh, the sun's rays fall at the feet of the deity on certain days. The early morning sun falls on the feet of the deity on summer solstice and winter solstice even when the five entrance gates are closed.

Modhera Temple: The temple too is known for its design that allows the rays of the Sun to fall at a particular place on certain days.

Gavi Gangadhreshwara Temple: Every year on the Makara Sankranti day, when the Sun enters Capricorn, rays of the sun fall on the Shivalinga inside the cave.

Vedanarayanawamy Temple: The rays of the sun fall on different parts of the de-

ity on different days every year. On the first day the rays fall on the feet, on the chest the next day and on the forehead on the third day.

Ram Janmabhoomi Mandir, Ayodhya: On Ramnavmi, devotees witnessed the Surya Tilak ceremony, the moment when the Sun's rays directly touch the forehead of the deity. This was made possible by the interplay of optics and mechanics. The Sun's rays were carefully directed to illuminate the forehead of the deity, serving as a profound symbol of reverence and devotion.

Thus, the intricate interplay of acoustics and optics within Hindu temples represents a profound fusion of science, spirituality, and architectural mastery. From the strategic placement of pillars and chambers to the careful design of sculptural elements and temple layouts, these ancient structures serve as living testaments to the depth of Hindu cosmology and the quest for spiritual enlightenment. Through the manipulation of sound and light, Hindu temples create immersive environments that engage the senses and elevate the worship experience. The use of sacred symbols, the arrangement of spaces, and the incorporation of natural elements all contribute to a holistic journey towards the divine.

**The writer is Associate Professor, Department of Physics, University of Lucknow.*



Legacy of Technology in Indian Architecture

As custodian of our cultural identity, India's contemporary architecture can play a vital role in instilling 'Indianness' in our built heritage



■ Prof Virendra Kumar Paul

Architecture happens to be the most profound storyteller about the glory of India. Civilizations around the world have employed architecture as an expression of their scientific advances, cultural identity, might of the rule, national pride, custodian of societal values, beliefs associated with spiritual journey and just the basic shelter sufficient for one's existence. Science and art as rock bed of architecture can only be a journey of excellence but never be perfected by any human being except for

the architect of the Universe, the Lord Vishwakarma. The divine architect, as Lord Vishwakarma is referred to in ancient Indian texts, can also be interpreted as a mighty intellect that alone can perfect the balance of science and art that is architecture.

CLIMATE, GEOGRAPHY AND ARCHITECTURE

Diversity is the sole typification of Indian architecture. If climate and geography are the two most significant influences that define human-nature relationship, they have driven the characterisation of architecture as well. However, the unifying factor across all regions has been the inseparable underlying 'Bhartiya-tatwa', the Indianness. This is evidenced in the architecture of temples of various time periods and regions. Despite their physical conditions, the scholarly works by archaeologists,

conservation architects, historians and masters of Indian Knowledge Systems have yet to unfold most of the legacy. An intervening period of the last 1000 years has conditioned reference of our interpretation of heritage to the invader's interests. Let us trace the technology legacy of Indian architecture briefly.

ANCIENT TECHNOLOGY WISDOM

Abundant literature has attempted to explain intrigue in form, scale and construction technologies in Indian temple architecture. Physical appreciation of magnificence is simple to connect with and so are some of the planning and design principles. There is another intangible layer of belief that is related to the principal deities and the depth of understanding depends on the level of internalization of knowledge by the individual devotees. Such devotees connect with external physicality of

Image Courtesy: Wikimedia Commons

a structure all the way to the deity in the Garbha Griha seamlessly as they transition through spaces conjugated by design having different scales, geometric proportions, spatial relationships, sound articulation of Martas, variations in reverberation times, effect of underlying story sculpted on interior surrounding embellishments and so on. Thus, the visualization of the Master Architect was beyond perception, created through physical exterior expression and also imagining the spatial design of the volume inside the structure in the same design, simultaneously.

Simply put, the technological genius of Indian Master Architects and constructors was to create one distinct external expression, and another one experienced inside as ‘Anubhav’ due to volumetric proportions and the detailing. So, the Master Architect was handling two different storylines in the same construction layer successfully. Indian temple architecture was beyond the realm of external manifestation of monumentality, but experiential expression conceptualised thoughtfully and executed to reality over decades involving generations of craftsmen. It is still an intrigue as to how design was communicated in its form and intent to the generations error free.

Recent excavations at Rakhigarhi have revealed remnants of a well-



Image Courtesy: World History Encyclopedia

Architectural excellence of later sites of the Saraswati-Indus Valley civilisation reveals a highly accomplished society. Above: Excavated remains at Mohenjodaro

planned township as a part of the Saraswati-Indus Valley civilization of 5000 BCE. Masonry houses having kitchens, toilets, and drainage systems are a reflection of a flourishing trade city. Although the civilization might have collapsed around 2000 BCE, the evolution of architectural excellence that we see at later stages must have been the result of a highly accomplished society. From city planning to temple towns and temples, ancient Indian architectural legacy represents a unique continuum of wisdom linking society, communities and livelihoods around. Irrigation and water management systems created by Cholas are the testimony of their pro-

found understanding of hydraulics but also the deep understanding of climate and geotechnical engineering.

CONTEMPORARY INDIAN ARCHITECTURE EXCELLENCE

Architecture is at the centre of creating a new India. The New Parliament Building at Central Vista New Delhi shall be remembered as a statement of creating our own national identity by leaving behind colonial tradition of the built form, thereby heralding a new India, marking Amrit Kaal of Viksit Bharat at 2047. In the journey of transformation into modern India, the Surat Diamond Bourse (SDB) building is a landmark accomplishment. Known as the ‘world’s largest office building’, it is designed to serve as a destination for over 65000 diamond professionals which will house over 4200 traders from 175 countries having its own ‘Customs Clearance House’ for import-export, a jewellery mall catering to retail jewellery firms and a facility for international banking and secure vaults. The SDB is projected to bring in a turnover of Rs 2 lakh crore.

When India hosted G-20 at Bharat Mandapam, New Delhi, it was in fact, a celebration of contemporary Indian architecture. India has at least two buildings completed in the ‘supertall category’ having height more than 300 meters (Palais Royale and Lokhandwala Minerva, both in Mumbai) and has at least four buildings under construction



Image Courtesy: PIB

India’s new Parliament building is a platinum-rated green structure, which reinforces our national identity by discarding built colonial traditions

(all in Mumbai). Known as the ‘financial and technological metropolis’, GIFT City (Gujarat International Finance Tec-City, in Ahmedabad district) is an architectural and planning marvel conceptualised on walk-to-work and quality of life principles. It is a global benchmark which will set standards for architecture and planning leading to realization of Viksit Bharat@2047.

Indian architecture practice has been leading the world’s largest ‘green building’ movement. Green sustainable technologies and systems being used in contemporary buildings for energy efficiency and water management are some of the most advanced in the world. Late Dr PC Jain, an engineer par excellence, who taught student-architects at the School of Planning and Architecture for almost four decades, pioneered Indian Green Building Movement under Indian Green Building Council in 2007, envisioning 10 billion sq. ft. of green building footprint by 2022, with the target of ‘one square foot of registered green building footprint for every Indian’. Today, India is the second country in the world in terms of registered green building footprint. As a result of the Indian Green Buildings initiative, there is a transformation of green products and technologies with a market potential of around 300 billion USD by 2025. Dr Jain, one of the most revered teachers, was a graduate from BHU where he got deeply inspired to serve the country. Having acquired a doctorate from the US, he returned to serve India and was a catalyst in involving one of the largest numbers of registered architects practicing green certified buildings in the world. Dr Jain, in his book, *Path of Green*, envisioned India to be ‘Jagatguru in a Sustainable Built Environment’.

At the Amrit Kaal of Viksit Bharat, India has the technologies to produce green and sustainable buildings as well as the critical mass of architecture professionals. Recent airport buildings, healthcare infrastructure buildings (such as numerous AIIMS projects dedicated to the nation already) and many other such projects in both private and public sector bear testimony to the po-



Image Courtesy: Pexels

Abundant literature has attempted to explain intrigue in form, scale and construction technologies in Indian temple architecture. Left: Shri Aadya Katyayani Shakti Peetham in Chhatrapur, New Delhi

tential capacity. The challenge now is to respond to climate change and engage in a net zero carbon sustainable development paradigm.

TRANSITIONING THE LEGACY OF INDIAN ARCHITECTURE TO FUTURE

As we move to the climax phase of reaching the goal of a developed nation, the development has to be sustainable, lest the development itself become the nemesis. Architecture practice is now transitioning from ‘green buildings’ to net-zero carbon footprint development. At this juncture, it is important to recall that Indian traditional architecture has evolved scientifically based on ancient wisdom. Sustainability has been at the core and consumptive needs were controlled through compatible lifestyles. The nation is now presenting traditional Indian wisdom of Lifestyles For Environment (LiFE) principles as a panacea for climate change to the world. For Indians though, it is reverting to our own roots. It is therefore incumbent to build new paradigm architecture on the foundations of ancient wisdom, traditional knowledge, and contemporary experience with technologies. The challenge, though, is to embrace technologies for global standards of lifelong measurement review and verification (MRV) of systems integrated in upcoming buildings. Verifiable outcomes during the operational phase of net zero performance of technologies and systems would necessitate digital twinning.

CUSTODIAN OF CULTURAL IDENTITY

Architecture is the most effective custodian of cultural identity. And Indian

architecture has a pivotal role in instilling national pride. Hence, architecture in India would now need to express Indianness, the Bhartiya Tatwa as it embraces cutting edge solutions. Hitherto, in recent times, the question of identity has been relegated to insignificance, but technology led architecture cannot afford to clone western urbanization.

Defining Indianness is a complex paradoxical issue. Can it be urban centric and roughshod villages where culture and value systems still flourish? Global architectural expressions have no relevance to the diverse rural settings in India while technological advances should not discriminate against the urban-rural divide. Rural India and its surroundings would have to be preserved as carbon sinks which should not be the reason for less than ‘modern’ facilities and amenities. Professional training pipeline is yet to create appropriate capacities since the architecture professional education is largely modelled around its service in urbanised context. This would call for transformation of professional architecture education in India addressing ‘art and science’ needs of villages, embracing technologies for MRV protocols and experimenting with adaptation of contemporary in contextually diverse regional realities in India. The wise amongst the architecture education and profession in India need to strategize for the dawn of new India @2047.

**The writer is Director, School of Planning and Architecture, New Delhi.*

EXPLAINER

The Great Indian Election: Science Behind Indelible Ink

The story behind the purple mark on index finger, the biggest symbol of India's thriving democracy

■ Science India Bureau

Amidst the ongoing great Indian Lok Sabha election jamboree of ballots and booths with a voter base of nearly 97 crore, lies a humble yet indispensable element — the indelible ink. More than just a mark on the finger, it symbolizes the essence of India's commitment to fair and free elections.

Beyond its functional role, indelible ink carries immense symbolic weight.

It signifies the solemn act of participating in the democratic process, a fundamental right and duty of every citizen. The ink-marked finger becomes a badge of honour, proudly displayed by voters as a testament to their contribution towards shaping the nation's destiny.

APPLICATION

The purple-coloured ink is applied on the left-hand index finger — across the skin and cuticle of the voter, in a polling booth. Once applied, the ink cannot be removed by any chemical, detergent, soap or oil for several months. The ink is used in all elections across the country. The objective is to prevent the person from voting for the second time in the same election and to prevent any fraudulent practice.

HISTORICAL BACKGROUND

In 1962, the Election Commission of India (ECI), in collaboration with the law ministry, National Physical Laboratory (NPL) and National Research Development Corporation (NRDC),



The ink-marked finger is a badge of honour, proudly displayed by voters as a testament to their contribution towards shaping the nation's destiny

made an agreement with Mysore Paints, a Karnataka government entity, for the supply of indelible ink for Lok Sabha and assembly elections.

The ink was first introduced during the Lok Sabha elections in 1962. Since then, it has been used in all elections in India.

SCIENCE BEHIND INDELIBLE INK

Indelible ink contains silver nitrate. It is a colourless compound which becomes visible when exposed to ultraviolet light, including sunlight. Silver nitrate used in the ink is caustic to skin. The ink dries out in less than 40 seconds and leaves a dark stain behind.

According to a United Nations Development Programme report, higher the silver nitrate's concentration — say around 20%, higher will be the ink's quality. After application of the ink, it can remain resistant to soap, liquids, home-cleansing, detergents, etc. for more than 72 hours.

“This water-based ink also contains a solvent like alcohol to allow its faster

drying. The precise protocol for making this ink including its chemical composition and the quantity of each constituent is, however, not known to many people,” mentions the government's MyGov website.

MAKERS OF INDELIBLE INK

It was during the tenure of India's first chief election commissioner, Sukumar Sen that the research work on formulating the indelible ink was initiated in 1950s by scientists in the erstwhile Chemical Division and was later patented by the NRDC, New Delhi.

The indelible ink was first manufactured at the ECI's request by the government's Council of Scientific & Industrial Research (CSIR).

After the ink was developed by the scientists at CSIR-NPL, the technology was transferred to Mysore Paints and Varnish Limited (MPVL), which has been the sole supplier ever since. MPVL was licensed to manufacture the ink and has been in the business since 1962. Earlier called Mysore Lac & Paint Works Ltd, it was established by Nalwadi Krishnaraja Wodeyar, the then Maharaja of Mysore, in 1937.

BEYOND INDIA

According to the news reports, 26.55 lakh bottles (vials) have been ordered by the ECI for Lok Sabha elections 2024 — the highest till date. A 10 ml vial can be used to mark fingers of nearly 700 people. India exports indelible ink to more than 25 countries, including Canada, Ghana, Nigeria, Mongolia, Malaysia, Nepal, South Africa and the Maldives.

SCIENCE & SPIRITUALITY

Galactic Cosmic Rays Rise During Spiritual Activities

SEVAN scintillators across the world have recorded a rise in cosmic ray activity during events of intense thought processes by humans on the earth



■ Prof Saumitra Mukherjee

It is a new finding in the field of science and spiritual activities to understand the connectivity of the individual human beings with the high energy particles of the Universe. It is a scintillating finding that during a concentrated thought process by human beings, the cosmic ray intensity per unit time on the Earth from the Sun and galactic sources rises. The thought processes may be

Yoga, prayer, music, dance or any other performing acts which need concentration of mind and body.

Using Space Environment Viewing and Analysis Network (SEVAN), 11 locations have been selected across the world to monitor the cosmic ray variability through scintillators of different thickness and one photomultiplier. These scintillators are made up of plastic materials. The instrument SEVAN was planned during the International Heliophysical Year 2007. It aims to improve the fundamental research of particle acceleration in the vicinity of the Sun and space environment conditions. This is a unique ground-based cosmic ray detector which measures a time series of secondary particles born in cascades



originating in the atmosphere by nuclear interactions of protons and nuclei accelerated in the galaxy. The data has been recorded in a continuous mode in all these stations and its centralized

hub is in Armenia. All the data is stored through Linux mode in the server in Armenia which can be retrieved by any user for scientific analysis purposes. It is needed to establish that concentrated prayer or any performing acts may improve the health condition of a community. The author acknowledges United Nations' peaceful research on outer space, and NASA, USA, for funding the patented hypothesis 'Influence of Sun and other cosmic factors on Earth's Space Weather Environment.'

FAITH AND SCIENTIFIC EXPLANATIONS

There are various incidences in our daily life which have so far no scientific explanation and we depend on our faith system to improve physical and mental health. These faith systems not only involve worshipping god but may also include music, sports, dance, speeches, etc., in which there is only one common factor, that is concentration. Globally, there are different faith systems and their manifestations have been described as miracles. In the history of science and spirituality, some work has been done but for the first time, a concrete proof

hidden fact of science in 1940 and published it in the journal, *Nature*. There were various correlations made with the cosmic ray and heliophysical variability and the natural or physical environment change. This is a precision effort to establish the relationship of the rise of galactic cosmic rays with concentrated prayer. Further, it has been experimentally proved that not only prayer but any concentrated thinking including studies and other positive activities can give rise to solar or galactic cosmic rays. Music and other performing arts and Yoga may play a big role in creating the niche for concentrating cosmic rays from the Sun and the galactic unknown sources.

The Sun-Earth cosmic connection to the environment of the Earth has been well established after repeated research investigations. Natural changes in the environment can be correlated with spiritual activities. Like winter, autumn, summer are environmental conditions while our internal emotions like love, happiness, anger, sacrifice, etc. are caused by the interaction of extra-terrestrial changes. These changes influence human organs to release different hormones which are caused by changes in the Sun, Moon, wind and stars. With spiritual activities, one may understand and can have control on the manifestations. It is possible to create changes in the environment of small to large entities by generating friction between opposite electromagnetic forces of the left and right hands by vigorously rubbing one against the other and some changes in the body and mood is observed.

The potential of prayers in the rise of cosmic rays of different origin, either from the Sun or distant galactic sources, is being established for the first time.

The rise in galactic cosmic rays has the potential to slow down the effect of the magnetic effects of the Sun. It is a temporary effect and is known as 'Forbears Decrease'.

A sudden rise in cosmic rays from the galactic sources has been observed after the prayer performed in the room of the SEVAN detector on the occasion of Maha Shiv Ratri of 20 Febru-

ary 2012. The SEVAN detector of JNU showed a sharp rise after mass prayer in Delhi and surrounding areas on Maha Shiv Ratri, which was due to concentrated thought processes.

Further, the rise in the cosmic rays has been seen on the day of World Yoga Day on 21 June 2015.

Another example of Armenia can be cited in support of the spirituality relation with cosmic ray variability.

On 5 October 2021, His Holiness Karekin II — Supreme Patriarch and Catholicos of all Armenians — departed for Rome (Italy) to participate in the 'People as Brothers and the Future of the Country: Religions and Cultures in Dialogue' conference and inter-church prayer, organised by Sant'Egidio Community. During the visit, thousands of Armenians met with His Holiness Pope Francis. The delegation members accompanying His Holiness, His Eminence Archbishop Khajak Parsamyan performed concentrated prayer in Armenia (as reported in the *Times*, Yerevan, 2021). It has been recorded in the SEVAN detectors operational at Aragats Space Environmental Centre on Mount Aragats in Armenia, that after the prayer there was sudden rise in cosmic ray intensity.

It is a universal belief that all the faith systems are actually spiritual activities across the world. Manifestation of the spiritual activities has been revealed to be the rise of cosmic rays recorded on the earth receiving stations like SEVAN. However, it is possible to have the manifestation recorded as speciation of cosmic rays based on its origin through different faith systems. In Indian context, the rise in cosmic rays during prayer and Yoga has been observed as a rise in galactic cosmic rays with unknown origin, however in other faith systems like Armenia, the rise in the cosmic rays from the Sun has been recorded. However, there was a low in the galactic cosmic rays during these events.

The rise of solar cosmic ray was coupled with the rise in the magnetic field, as recorded by using Sun Observatory Heliophysical Activity (SOHO) satellite

Image Courtesy: Shutterstock



Image Courtesy: PIB

based on high energy particle variations and its correlation with our prayers are being presented here with ever stronger proofs. World renowned scientist Albert Einstein discussed the possibility of this

on 22 and 23 October 2021, in between the Sun-Earth Environment, which is also known as Kp values.

The rise in galactic cosmic rays has the potential to slow down the effect of the magnetic effect of the Sun. It is a temporary effect and is known as 'Forbears Decrease'. It has been observed in different time scales that the nebular blast and changes in the stellar constellation have an impact on the sun. SOHO inferred helioseismological investigations primarily aim at the study of those parts of the solar oscillations spectrum that cannot be obtained from the ground. The required sensitivity for observing the very low modes and the high modes is difficult to achieve from the ground because of noise effects introduced by the Earth's diurnal rotation for the low modes, and the transparency and seeing fluctuations of the Earth's atmosphere for the high modes.

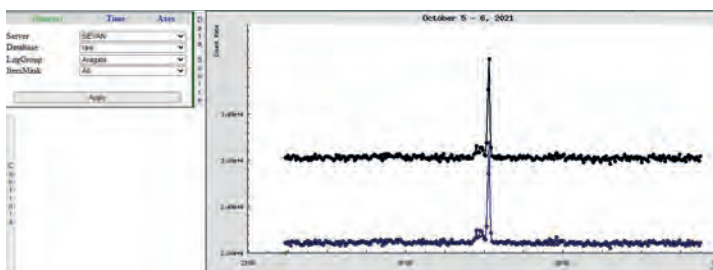
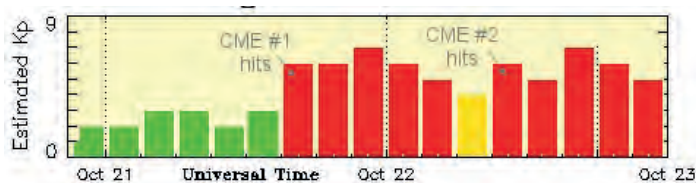
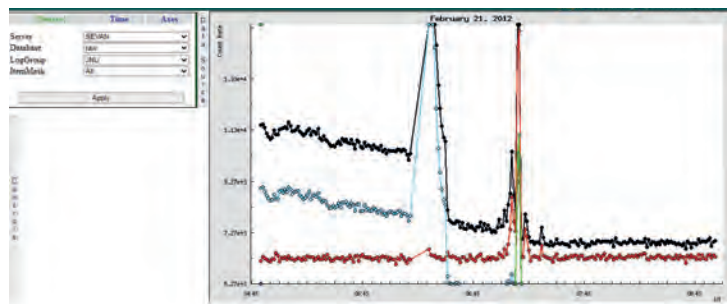
SOLAR ATMOSPHERIC REMOTE SENSING

The solar atmosphere remote sensing investigations are carried out with a set of telescopes and spectrometers that will produce the data necessary to study the dynamic phenomena that take place in the solar atmosphere at and above the chromospheres. The plasma is being studied by spectroscopic measurements and high-resolution images at different levels of the solar atmosphere. Solar Plasma diagnostics obtained with these instruments provide temperature, density, and velocity measurements of the material in the outer solar atmosphere.

It has been revealed by leading scientists across the world that there are influences of extra-terrestrial changes on the environment of the Earth, however this is the first time it is established that manmade spiritual activities can influence the extra-terrestrial impact on the Earth. The science of spiritual activities and the extra-terrestrial changes needs to be strengthened by different groups of scientists who have faith in spiritualism.

The relationship between spiritualism and science is the subject of continued debate in philosophy and theology.

Cosmic Ray Activity Measured



Top: Sudden rise in cosmic rays from galactic sources has been observed after the prayer performed in the room of SEVAN detector on Maha Shiv Ratri of 20 February 2012

Middle: Severe geomagnetic storm observed after 21 October 2021

Bottom: Sudden rise in cosmic ray activity from the Sun and galactic sources measured by SEVAN detector at Mount Aragats, Armenia, in the early hours of 6 October 2021 after the prayer

To what extent are spiritual activities and science compatible? Are spiritualism beliefs sometimes conducive to science, or do they inevitably pose obstacles to scientific inquiry? The interdisciplinary field of 'science and spirituality' also called 'theology and science', aims to answer these and other questions.

It studies historical and contemporary interactions between these fields and provides philosophical analyses of how they interrelate. It has been established that concentrated prayer improves general health conditions by the concen-

tration of the solar and galactic cosmic rays which creates physical and mental health conditions of not only human beings but possibly other animals and plants as well.

**The writer is a Former Dean and Professor, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi. Currently, he is a Director (Geology, Remote sensing and Space Sciences), New Environment and Energy Research, Greater Noida.*

INFOSYS PRIZE/ **PROF ARUN KUMAR SHUKLA**

Understanding GPCR Biology for Safer Medications

Prof Shukla's study has wide implications on designing medications free of side-effects



■ Dr Saurabh Tomar

Prof Arun Kumar Shukla, a structural biologist and a professor in the Department of Biological Sciences and Bioengineering at the Indian Institute of Technology, Kanpur, has won the prestigious Infosys Prize 2023 in Life Sciences, for his contributions to the understanding of G-protein coupled receptors (GPCRs), a crucial aspect of cellular activity.

This prize is a recognition of Prof Shukla's research which produced beautiful illustrations of the mechanics behind the selective activation of signalling pathways downstream of GPCRs. These and other findings offer a basic comprehension of the roles of GPCRs and propose a fresh approach to the development of innovative treatments.

All live cells move 'information' throughout the cell, in order to maintain the basic operations of the cell. The ongoing 'trafficking' of information is done by protein molecules known as 'receptors'. The largest and most significant of these receptors are GPCRs that are found on the cell's surface and react to different stimuli from the outside world. They perform tasks essential for regulating numerous bodily processes, including development, hormone re-

sponses, and feelings. Furthermore, medications for a variety of illnesses, including mental disorders, cancer, hypertension, and cardiac diseases, target GPCRs. It is estimated that between one-third and half of all medications function by binding to GPCRs. A deeper comprehension of GPCRs can aid in the development of medications with few side effects and maximum effectiveness.

However, life-saving drugs may not only cause severe side effects, but can also cause resistance for medications for various other diseases.

Understanding GPCRs in terms of their structure, function, and regulation is the focus of Prof Shukla's study.

GPCRs are a key component of signalling, whose dysregulation may cause brain illnesses, malignancies, heart ailments, and developmental anomalies. According to Prof Shukla's research, agonists—specific activators that selectively engage one of the two key pathways downstream of GPCRs—can reduce the adverse effects of frequently prescribed medications. The idea of biased agonists with the ability to control GPCR signalling can be used to create medications for various human illnesses.

Prof Shukla has successfully developed a platform for synthetic antibody technology and used it to construct modulators to regulate GPCR trafficking and signalling, and sensors to investigate GPCR activation. These instruments have broad ramifications on

hitherto undiscovered facets of GPCR biology. Understanding the structural biology of membrane proteins, like GPCRs and their signalling complexes, is a key component of his study program.

Using a framework for synthetic antibody technology, Prof Shukla's lab has created sensors that examine the operations of GPCRs and in the creation of national cryo-electron microscopy facilities—a technique that is essential to the advancement of basic science in India. He has built small 'nanomachines' through which he has discovered that even a single alteration in GPCR can affect its interaction with other proteins and become activated. His research data can be used to build more effective medications with precise cell targeting.

An MSc from JNU, New Delhi, Prof Shukla completed his PhD at the Max Planck Institute of Biophysics in Frankfurt, Germany. Prior to joining IIT Kanpur in 2014, he worked as a research associate and assistant professor at Duke University, North Carolina.

He received the DBT Wellcome Trust India Alliance Senior Fellowship, National Bioscience Award (2018) and the Shanti Swarup Bhatnagar Prize (2021).

**The writer is a postdoctoral fellow in the department of Mathematics, IIT Kanpur, doing research in the field of Numerical Analysis. He holds a joint MSc-PhD in Mathematics from IIT Kharagpur.*



Prof Arun Kumar Shukla (second from right) receiving the Infosys Prize 2023 for Life Sciences earlier this year

Image Courtesy: IIT Kanpur

IN FOCUS: RAJA RAMANNA CENTRE FOR ADVANCED TECHNOLOGY, INDORE

Vital Tech Support to Giant Global Missions

RRCAT is at the forefront of developing non-nuclear technology and has been an integral part of projects such as Chandrayaan and Large Hadron Collider



■ Prof Kumud Das

Raja Ramanna Centre for Advanced Technology (RRCAT) at Indore in Madhya Pradesh came into existence after a formal order issued by the eminent physicist and then director general of Defence Research and Development Organisation (DRDO), Padma Vibhushan Dr Raja Ramanna in 1983. RRCAT, a premier R&D facility engaged in non-nuclear frontline research areas of lasers, particle accelerators and related technologies, is a unit of the Department of Atomic Energy, Government of India.

THE CENTRE

The centre's foundation stone was laid by the President of India, Gyani Zail Singh on 19 February 1984. At the time, it was named the Centre for Advanced Technology (CAT). Former Prime Minister Dr Manmohan Singh renamed the centre as Raja Ramanna Centre for Advanced Technology (RRCAT) on 17 December 2005.

RRCAT is a delivery-oriented R&D organization conducting research and development in non-nuclear, front-line



research areas. These areas include light sources like lasers and particle accelerators, their applications, and related technologies such as plasma, ultra-high vacuum, charged particle dynamics, electromagnetics, radio-frequency engineering, precision manufacturing, material joining, and cryogenics. The centre's motto is: "Photons serving mankind through science and technology."

One of the centre's most significant achievements is the indigenous development of particle accelerators at a significantly lower cost compared to similar international facilities. Despite this cost advantage, the performance of these technologically complex machines



Below: Raja Ramanna Centre for Advanced Technology (RRCAT), Indore; Bottom: Indus complex of the institute; Right: Medical products under sterilization using 10 MeV, 6 kW linear accelerator at RRCAT



remains at par with international facilities in terms of uptime, research papers published, and beam characteristics.

The centre has successfully designed and built two electron accelerator-based synchrotron radiation sources: Indus-1 (450 MeV, 125 mA) and Indus-2 (2.5 GeV, 200 mA). These national facilities serve researchers from across the country.

The Indian pharmaceutical industry routinely conducts experiments at Indus beamlines to validate their drug development processes and obtain crucial data for licensing purposes. The synchrotron beamlines of Indus facilities have also played a vital role in calibrating software and detectors for ISRO's Chandrayaan-I and Chandrayaan-II missions, as well as characterizing X-ray optics for its Astrosat mission. Additionally, the nuclear industry has benefited from Indus-2 beamlines through stress analysis of critical welded components used in reactors.

The centre has mastered the technology of building indigenous 10 MeV linear electron accelerator for medical sterilization and various other applications like agro-produce preservation, irradiation of research samples for the development of new crop varieties, colour modification of gemstones, development of novel materials and modification of semiconductor properties. An ISO 9001-certified 6 kW electron beam

radiation processing facility is fully functional and is operating commercially at Devi Ahilya Bai Holkar Fruit and Vegetable Mandi Complex, Indore.

HOME-GROWN ELECTRON BEAM PROCESSING EXPERTISE

RRCAT has also developed fully home-grown electron beam processing expertise in strict compliance of ISO 11137 as well as AERB and FDA regulations. The radiation processing facility has been providing electron beam radiation processing services for the sterilization of medical devices on a commercial basis. More than 2.5 million medical devices have been sterilized in this facility. Another 10 MeV, 10 kW industrial linear accelerator has been installed at an industry in Bangalore for industrial scale process operations for medical device sterilization. The RRCAT team carried out intensive activities with the industry for installation, beam commissioning and performance qualification of this critical, large-scale system at Bangalore. Further activities for equipment, plant, process and product regulatory approvals are to be carried out in the coming weeks. RRCAT has already embarked on its efforts to increase the beam power to 15 kW in the coming times.

It is significant to note that the whole of the 27 km Large Hadron Collider

(LHC) of CERN, Geneva, is standing on RRCAT's six thousand eight hundred ultraprecision alignment jacks. These jacks were conceptualised and designed at RRCAT and were manufactured by the Indian industries under the quality surveillance of RRCAT. The jacks are capable of positioning a 15-meter-long magnet, weighing 32 tonnes, with an accuracy of less than 50 micrometres, i.e., less than the breadth of human hair. RRCAT also made several other contributions in LHC like manufacturing of superconducting corrector magnets and performing characterisation of huge superconducting magnets.

ACE MANUFACTURER OF SENSITIVE COMPONENTS

Manufacturing technology plays a crucial role in delivering complex and technically challenging products. One of the early challenges faced by the centre was in the manufacturing of precision and dimensionally sensitive components in materials like pure copper, stainless steel and aluminium and its alloys that must meet additional requirements of ultra-high vacuum compatibility. This required cutting-

edge research in material joining as these complicated machines need a variety of metals and ceramics for their specific properties. These joints must be of the highest quality due to the compulsion of achieving ultra-high vacuum. This requirement was foreseen by great visionaries of DAE and a small workshop building was inaugurated only after three years of laying of foundation stone. Today, this facility has state-of-the-art design, manufacturing and measurement tools powered by a very committed and dynamic team of about 100 technocrats who work tirelessly to convert dreams into reality.

The 1.8-meter-long linear electron accelerators of radiation processing facilities, made of ultrapure copper, are manufactured in RRCAT's facility starting from raw material to the end product. Engineering marvels like radiofrequency cavities of Microtron, Booster Synchrotron, Indus-1 and Indus-2 are some of the shining examples of the competence of the facility. This facility has equipped RRCAT to develop recipes for dissimilar bi-material joining of materials like tantalum, niobium,

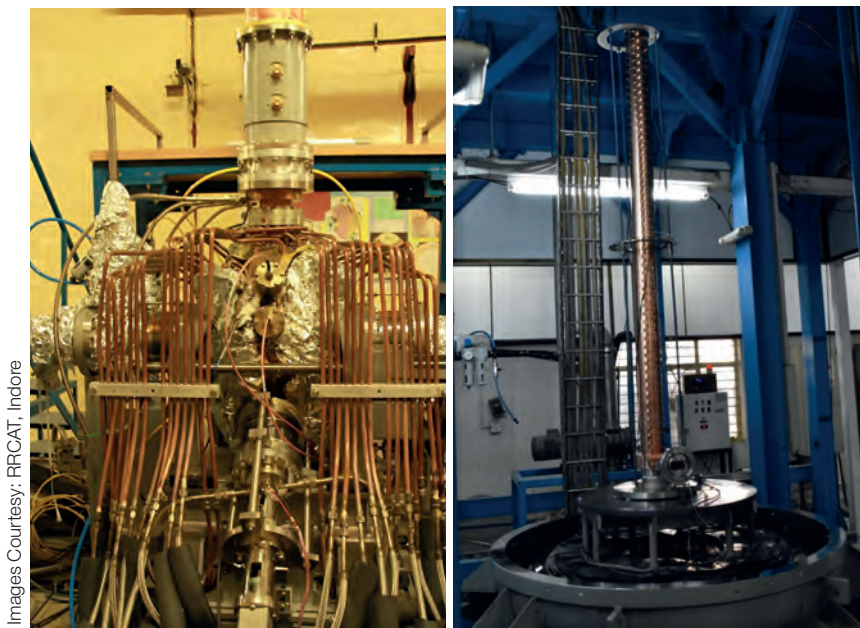
alumina, stainless steel, titanium and its alloys, copper, aluminium and its alloys, molybdenum, aluminium nitride and silicon carbide. It has also developed novel processes in fusion welding of austenitic stainless steels and some non-ferrous metals to meet the design goals emanating from the requirements of particle accelerators.

Recently, RRCAT conducted a one-of-a-kind theme meeting on recent advances in TIG welding of stainless steels, aluminium alloys and titanium alloys with the participation of 150 delegates from academia, research labs and industry on one platform. It has also demonstrated the ability to make vacuum-cast thread-filled tubular joints between aluminium alloy and austenitic stainless steel for a prospective application in an isotope production reactor. It is always working towards developing novel joining technologies much before their need appears in projects.

CONTRIBUTING TO NUCLEAR POWER REACTORS

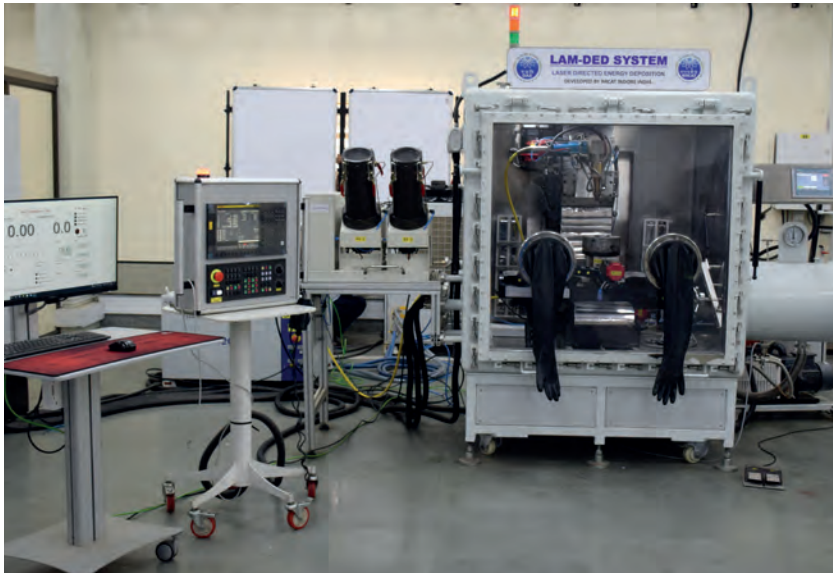
RRCAT has also developed the capability of manufacturing superconducting radiofrequency cavities made of niobium which are crucial for the development of accelerator-driven sub-critical nuclear power reactors fuelled by thorium. India has enormous reserves of thorium; therefore, this capability will assist in the development of thorium fuelled nuclear power reactors.

The manufacturing technologies developed at RRCAT are also resolving challenges on various other fronts. RRCAT has developed high-power long pulse Nd:YAG lasers of up to 1 kW average power and 20 kW peak power. Laser cutting and welding technology has the advantage of non-contact nature, remote operation, lower heat affected zone, distortion and shrinkage as compared to conventional technologies. Remotely operable laser cutting technology has been developed & deployed successfully for various in-situ operations such as cutting of bellow lips during en masse coolant channel replacement (EMCCR) campaign, removal of single selected



Images Courtesy: RRCAT, Indore

Left: In-house manufactured Indus-2 radiofrequency cavity at RRCAT; Right: Vacuum brazing to manufacture 1.8-meter long linac for radiation processing



RRCAT developed Laser Additive Manufacturing System

coolant channels for post-irradiation examination for life enhancement studies, cutting of up to 30 mm thick pipelines, etc. for refurbishing and maintenance of Indian nuclear power plants. The use of laser-based technology has resulted in enormous reduction in maintenance shutdown time of reactors as compared to conventional mechanical methods. For societal applications, laser micro-welding technology for I-125 and Ir-192 brachytherapy capsules for cancer treatment and heart pacemaker fabrication have also been developed. Towards the front end of the fuel cycle, laser welding technology for fuel pins has also been successfully developed and deployed.

RRCAT has developed machine vision-based inspection systems to assist fabrication of nuclear fuel. Machine vision system refers to the human-like ability of an intelligent machine with the capability to capture the visual information; decode, analyse it and make interpretations. The machine vision-based system has replaced the human intensive inspection procedures leading to a substantial reduction of radiation exposure. This accurate, non-contact, fast, 24x7, industrial-grade, customized inspection system is a perfect fit for integration into the existing production cycle.

RRCAT's laser additive manufac-

turing (LAM) technology for building metallic components stands at the forefront of innovation. RRCAT's additive manufacturing endeavours have led to the development of cutting-edge LAM systems and metallic components for in-house and industrial applications. The technology is now being commercialized through industry and startups. The centre has also built unique products using cold additive manufacturing technologies like electroforming by electrochemical deposition on removable mandrill or conductivised wax.

TRANSFERRING TECH TO INDUSTRY AND MARKET

The technologies and products developed at RRCAT for specific applications are transferred to the Indian industries and startups under its incubation programme. AIC RRCAT PI-HUB FOUNDATION (also known as AIC π-Hub) is a Section-8 company incorporated under the Companies Act 2013 with 100% equity holding by the Centre and is supported by Atal Innovation Mission. It is mandated to translate technologies, know-how, and expertise developed at RRCAT into products or processes for the Indian industries or startups with the seamless handholding of RRCAT scientists and

engineers. Many of the technologies and products developed at RRCAT have been transferred to the Indian industry through various modes of incubation.

RRCAT has been making consistent efforts to take its technological strength to serve the nation in as many ways as possible. Trade Apprenticeship Scheme at RRCAT, popularly known as TASAR, is one such unique initiative in which ITI-passed young boys and girls are trained in their respective trades for one-year. They not only learn during their training but also make a substantial contribution to the overall physical output of the centre. The skill enhancement of these apprentices is so phenomenal that they are readily absorbed in top institutes and business firms. Some of the top recruiters of these apprentices are BARC, NFC, RRCAT, IGCAR, ISRO, DRDO, NISER, NPCI and Indian Railways. So far, RRCAT has trained more than 200 apprentices in various trades.

RRCAT's enviable journey from its inception to the present shows its commitment to deliver mandated products and associated technologies. The knowledgeable and enthusiastic scientists and technologists of the centre are ready to take up challenging assignments and are always looking forward to exceeding the expectations of the nation through exemplary work.

THE CAMPUS

RRCAT is situated on a sprawling 680 hectare-area campus on the southwest outskirts of Indore city. Currently, the campus covers over 255 hectares, including about 40 hectares of the scenic Sukhniwas Lake. This campus includes laboratories, offices, and a staff housing colony, as well as basic amenities such as schools, sports facilities, a shopping complex, a medical dispensary, a bank, a post office, a conference center, two community centers, three hostels, two guesthouses, and several beautifully landscaped parks.

**The writer is Associate Professor, DY Patil International University, Akurdi, Pune.*



HERB HERITAGE: MULETHI

Common Spice but an Array of Medicinal Properties

Mulethi or licorice is mentioned across several important Ayurvedic texts for its wide range of uses in medical conditions

When you get a cough, do any of your family members advise you to keep mulethi in your mouth for relief or offer you ‘*adrak mulethi ki chai*’?

Mulethi or licorice is a very common Bharatiya household spice and a potent Ayurvedic medicinal plant with immense health benefits in its roots. The botanists call it by the name *Glycyrrhiza*, which is derived from the Greek terms ‘glykos’ meaning sweet and ‘rhiza’ meaning root.

Licorice root is used in more than 252 Ayurvedic formulations, among which 179 are used internally and 69 externally. With more than 22 dosage



■ Vaidya Preeti Bhosle

forms, it is used in about 55 disease conditions.

Charak Samhita mentions 86 formulations, *Sushruta Samhita* mentions 27, *Ashtanga Hridayam* 45, *Shranga-dhara Samhita* 31 and *Bhavaprakasha* 63. Among these, 27 are used in *vatarak-ta* (gout), 24 in *juvara* (various fevers), 17

in *vrana* (various types of wounds), 15 in *netraroga* (eye disease), 14 in *visharoga* (various acute infectious/ poisoning condition), 12 in *viasrpa* (erysipelas like skin issues), 9 in *kushtha* (skin disease), 8 in *vajikarana* (aphrodisiac), 7 in *rasayana* (rejuvenator) and *mukharoga* (mouth disease), etc. For a variety of medical applications, these formulations are made as different dosage forms like *taila*, *ghrita*, *gutika*, *arishta*, *avleha*, *kashaya*, *varti*, *kwatha*, *lepa* and *churna*.

It is known by various names across the country, such as :

Sanskrit: Yashtimadhuh, madhuka

Hindi: Jothi-madh, Mulethi

English: Licorice, Liquorice, Sweet wood

Bengali: Jasthimadhu, Jaishbomodhu

Kannada: Yashtimadhuka, atimadhura

Gujarati: Jethimadhu

Malayalam: Iratimadhuram

Marathi: Jeshtamadha

Oriya: Jatimadhu

Tamil: Atimadhuram

Telugu: Atimadhuram, Yashtimadhukam

Arab: Aslissiesa

Persia: Ausarehamahaka

France: Boisdoux

Germany: Sussholz

Licorice is Sheeta (cold) in nature, Guru (heavy) to digest, and Madhura (sweet) in taste. It is beneficial for eye problems due to its Chakshushya (good for eyes) property, and improves strength because of its Balya (strength provider) property. It also helps in improving sperm and semen quality due to its Shukral property.

Researchers have discovered over 300 phytochemical compounds in Mulethi roots that have antioxidant, anti-inflammatory, antibacterial, anti-cancer, and anti-diabetic properties.

According to its Ayurveda pharmacological properties, *Charak Samhita* has categorised Yashtimadhu in the following segments -

Jivaneeya: Promotes longevity

Sandhaneeya: Helps in bone fracture healing and wound healing

Varnya: Improves skin complexion

Kanthy: Improves voice

Kandughna: Relieves itching sensation (pruritis)

Image Courtesy: Shutterstock

Chardinigraha: Relieves vomiting

Shonitasthapan: It checks bleeding

Mutravirajaneeya: Restores proper colour of urine

Snehopaga: Used in Snehana

Vamanopaga: Used in Vamana (emesis)

Asthapanopaga: Used in Basti Karma (rectal enema with decoctions)

Ayurveda defines Mulethi's mode of action as *vata pitta* pacifying, *daba shamana* (pacifies burning sensation), *keshya* (beneficial for hair), *vedana sthapana* (pain/ sensation management), *shothahara* (anti-inflammatory action), *nadibalya* (strengthening to nerves), *medhya* (intellect promoting), *chhardi nigravana* (stops vomiting), *trishna nigravana* (pacifies thirst), *vata anulomana* (carmination), *mridu virechana* (mild purgation), *shonita sthapana* (haemostatic), *kapha nissaraka* (expectorant), *kanthya* (beneficial for throat), *mootrala* (diuretic), *mootra virajaneeya* (removal of abnormal colours of urine), *shukra vardhaka* (promotes formation of semen), *varnya* (complexion promoting), *kandughna* (pacifies itching), *jwaraghna* (management of various fevers), *jeevaneeya* (vitaliser), *sandhaneeya* (union promoting), *rasayana* (rejuvenator), *balya* (general tonic) and *chakshushya* (beneficial for eye disorders).

Ayurveda describes Yashtimadhu's medicinal uses in a lot of clinical conditions:

- Vranashotha (inflammation of wound or ulcer)
- Visha (toxicity)
- Khalitya (falling of hairs)
- Palitya (graying of hairs)
- Shastrabhighataja vrana (wound due to weapons)
- Vatavikara (disorders due to vata)
- Vatarakta (gout)
- Amavata (rheumatoid arthritis)
- Shiroroga (diseases of the head)
- Vamana (vomiting)
- Trishna (thirst)
- Vibandha (constipation)
- Udarashoola (pain in abdomen)
- Amlapitta (hyperacidity)
- Paittika apasmara (epilepsy due

to pitta)

- Hikka (hiccough)
- Raktavikara (blood disorders)
- Raktalpata (anaemia)
- Raktapitta (bleeding tendency)
- Shwasa (dyspnoea)
- Kasa (cough)
- Swarabheda (hoarseness of voice)
- Yakshma (tuberculosis)
- Urogata vrana (lung abscess)
- Parshwashoola (pain of pleurisy)
- Mootrakrichchhra (difficulty in micturition)
- Pooyameha (passing of pus in urine)
- Paittika prameha (diabetes due to pitta dosha)
- Shukrameha (passing of semen in urine)
- Varnavikara (disorders of complexion)
- Kandu (pruritis)
- Charma roga (skin disorders)
- Jeerna jwara (chronic fever)
- Samanya daurbalya (general weakness)
- Netra roga (eye diseases)

There are certain clinically proven Ayurveda remedies with Mulethi which can be safely used for managing certain non-acute conditions (it is strongly advised to consult an Ayurveda physician for seeking any guidance related to herbs/ medicinal plants) :

- Dressing wounds with Mulethi powder mixed with ghee promotes better healing and reduces pain.
- The oil prepared from Yashtimadhu, fresh *amla* fruit with cow's milk is used as *nasya* (putted into nostrils) to reduce hair fall.
- The intake of Yashtimadhu's powder with milk acts as *rasayana* (rejuvenating) particularly in promoting intellect.
- In case of hoarseness of voice, the *paayas* (rice with milk) prepared with it and mixed with ghee can be taken.
- In case of pain in the head, the affected parts when sprinkled with a mixture of milk and decoction of Yashtimadhu, get relief.
- In epilepsy, it is pounded with *kushmanda* juice and is given for three days.
- Yashtimadhu mixed in cow's milk

with *sharkara* (sugar) promotes lactation.

- The milk processed with Yashtimadhu, *sharkara* and *kaashmarya*'s bark promotes growth of the foetus.
- Yashtimadhu mixed with *amla*, *guda* (jaggery) and sugar is used in urticaria.
- Its pressed snuff mixed with honey can be used in cases of hiccough.
- The paste of Yashtimadhu mixed with *nimba*, *haridra*, *daruharidra*, *nishotha* along with *ghee* acts as a wound cleaning agent.
- Its decoction with *patola*, *katuka*, *musta* is useful in treatment of *visham jwar* (fever repeating at definite interval).
 - Its decoction made with *bilva*, *usheer*, *utpala*, *netrabala* and *shunthi* is taken with honey to pacify *pittaja atisaar* (diarrhoea due to *pitta dosha*).
- The *ghee* made with Yashtimadhu, *shunthi*, *sharkara* and honey is useful in *vataja asrigdara* (metrorrhagia due to *vata dosha*)
- The *ghee* made with Yashtimadhu, *kharjura*, *mridwika*, *parushak* and *pippali* pacifies the symptoms like *swarbheda*, *kasa*, *shwasa* and *jwara* present in *raajyakshma* (TB like conditions)

Modern science researches have also re-iterated the following pharmacological properties of licorice:

- Antilucer Activity
- Antitussive and Expectorant Activity
- Skin Protecting Activity
- Protective against side effects of Radiation/Chemotherapy
- Protective Effect in Liver Diseases
- Anti-Microbial Activity
- Anti-Viral Effects
- Hypocholesterolaemic and Anti-Oxidant Effects
- Protective Effects in Focal Cerebral Ischemia
- Anti-Helicobacter Pylori Effect
- Anti-Thrombotic Effect

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

Indian scientists reveal the reason behind crash of 38 SpaceX satellites

A unique blazing trail descending from space was witnessed in several parts of the world in February 2022. After some investigation, it was discovered that they were satellites, despite the initial theory that it was a disintegrating meteor. These were new Starlink satellites that SpaceX had launched a few days earlier. Indian researchers have now examined how the space weather contributed to their explosive descent from orbit. The results have been pub-



Disintegration of Starlink satellites indicates effects of space weather

lished in the American Geophysical Union journal *Space Weather*. There has been a steady increase in the use of Low Earth Orbit (LEO) satellites by humans for a variety of applications, including defence, telecommunication, navigation, and Earth observation. The effects of space weather on LEO satellites have only now come to light.

Solar eclipse on demand

India is getting ready to launch a mission that may produce an eclipse on demand, as the excitement over the Total Solar Eclipse of April 8 following a breathtaking display of the Sun, the Moon, and the Earth aligning in a straight line showed the interest this subject generates in the people. The Proba-3 spacecraft of the European Space Agency will be launched by the Indian Space Research Organisation (ISRO) to artificially replicate the celestial phenomenon in the frigid depths of space. In order to investigate



ESA's Proba-3 spacecraft may be able to produce a solar eclipse on demand

the Sun's weak corona closer to the solar rim than has ever been possible, Proba-3 will be the first spacecraft to perform a precise formation flying mission. Two satellites will fly together and form a 144-meter solar coronagraph.

SpaceX deploys Tata and Satellogic's TSAT-1A satellite

The TSAT-1A satellite, which was created by Tata Advanced Systems Limited (TASL) in collaboration with Satellogic Inc., has been successfully launched and placed into orbit by SpaceX. The Falcon 9 rocket of SpaceX was launched from Florida's Kennedy Space Centre. TASL and Satellogic collaborated to create the TSAT-1A satellite, which was assembled at TASL's Assembly, Integration, and Testing (AIT) facilities in Vemagal, Karnataka, beginning November 2023. Through this collaboration, TASL's strength in complex system integration and Satellogic's expertise in constructing cutting-edge Earth observation satellites are combined.



Tata Advanced Systems' TSAT-1A satellite was launched by SpaceX

Bengaluru's C-CAMP develops platform for studying single cells

A new platform that facilitates and lowers the cost of studying single cells has been developed by the Bengaluru-based Centre for Cellular and Molecular Platforms (C-CAMP) under the Department of Biotechnology. It is known as OptiDrop, and it has potential uses in the domains of medicine, agriculture, animal health,



C-CAMP's OptiDrop has potential uses in medicine and agriculture

and diagnostics. The journal *Nature Microsystems and Nanoengineering* published the results of the OptiDrop investigation. A specific type of test used to examine the properties of cells or particles is called flow cytometry. In flow cytometry, fluid-suspended cells or particles are introduced into the apparatus for analysis. One of India's leading hubs for biosciences research and innovation, C-CAMP was founded in 2009.

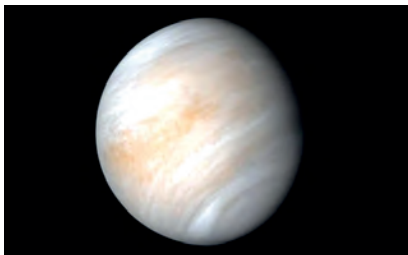
Fossils of massive prehistoric snake found in Gujarat

Fossils of a gigantic snake that lived approx. 47 million years ago during the Middle Eocene epoch have been found by researchers of Indian Institute of Technology (IIT) Roorkee. The reptile, known as Vasuki Indicus, may have been as large as a school bus or anywhere between 10 and 15 metres long as per the fossils discovered in Kutch, Gujarat. Though it belonged to the now-extinct Madtsoiidae snake family, it indicates a distinct lineage from India. The finding may advance the knowledge of the mechanisms underlying enormous body sizes and the evolution of the madtsoiid species under a variety of climatic conditions.

All Images Courtesy: Internet

Venus is leaking, European probe makes stunning discovery

According to a study, gases, including oxygen, are vanishing from Venus' upper atmosphere, which is significant for understanding how the planet lost its water. The joint European and Japanese mission BepiColombo

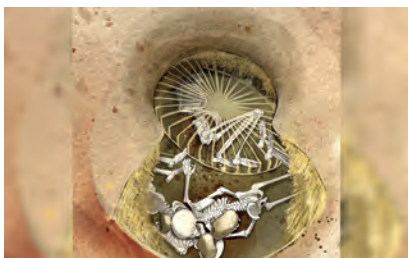


Carbon and oxygen ions are escaping from Venus' magnetic environment

conducted its second fly-by of Venus in 2021 while travelling to Mercury and discovered that carbon and oxygen ions were escaping from the uncharted area of the planet's magnetic environment. The study of this observation was published in the journal *Nature Astronomy*. BepiColombo recorded the quantity and mass of charged particles it encountered over a ninety-minute duration, providing insights into the physical and chemical mechanisms underlying air escape in the magnetosheath's side.

Humans were sacrificed across Europe in Stone Age

During the Neolithic era, ritualised human sacrifice was widespread throughout Europe, according to recent findings by archaeologists. Recent research has shown evidence of these ceremonies included the strangling, binding, and burial of women alive.



Evidence found of human sacrifice across Europe in Neolithic times

Archaeologists made the discovery after examining female skeletons that they had discovered in a tomb in the Rhone Valley of France. Two of the females' bones were discovered with their necks tied to their legs behind their backs, effectively strangling themselves, according to a report published in the journal *Science Advances*. Between 4000 and 3500 BCE, women were subjected to ritualistic abuse known as *incaprettamento*.

Russia launches ambitious Angara-A5 rocket after delays

Russia has successfully launched the Angara-A5 rocket from the Vostochny Cosmodrome. The difficulties encountered in the risky field of space technology are highlighted by the fact that this launch follows two earlier efforts that were cancelled due to a sequence

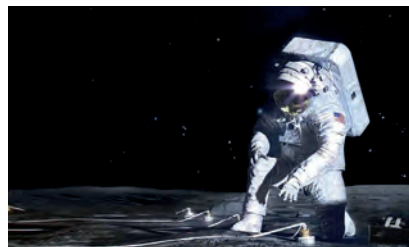


Russia's Angara-A5 rocket ultimately lifts off from Vostochny Cosmodrome

of technical mishaps. Nestled in the woods of the Amur region in Russia's Far East, the Vostochny Cosmodrome was the site of great excitement as the Angara-A5, a heavy-lift rocket intended to launch payloads over 20 tonnes into orbit, blasted into the sky.

Japanese astronaut to be first non-American to land on Moon

A Japanese astronaut will be the first person other than an American to set foot on the moon, US President Joe Biden disclosed during a press conference with Japanese Prime Minister Fumio Kishida. This advancement is a component of NASA's expansive Artemis programme, which intends to send people back to the moon for the first time since the Apollo missions' conclusion in 1972. During Prime



US-Japan collaborate to send Japanese astronaut to Moon

Minister Kishida's state visit, Washington's efforts to strengthen ties with its important Asian partner were demonstrated by the collaboration between the United States and Japan. Biden emphasised the importance of this relationship by saying, "Two Japanese astronauts will join future American missions, and one will become the first non-American to land on the Moon ever."

Nobel Prize winning Physicist Peter Higgs dies at 94

The University of Edinburgh announced in a news statement that physicist Peter Higgs, the winner of the Nobel Prize in physics, had passed away at the age of 94 on April 8. In 1964, while working as a researcher at the University, Higgs made the discovery that the God particle existed. In 2012, over 50 years later, investigations conducted at the European Organisation for Nuclear Research (CERN) in Switzerland supported his concept. The year 2013 saw the discovery and the granting of the Nobel Prize in Physics to Higgs, which he shared with François Englert. Higgs became a Professor Emeritus after retiring from the University of Edinburgh in 1996. Still, he saw experiments at CERN in Geneva at the Large Hadron Collider particle accelerator.



Peter Higgs was a co-winner of the 2013 Nobel Prize in Physics

Quiz: National Technology Day

1. May 11 is celebrated every year as the National Technology Day in India to commemorate the country's successful nuclear test in Pokharan in...

- A. 1974
- B. 1975
- C. 1998
- D. 1999

2. Which of the following luminaries declared the celebration of National Technology Day?

- A. Dr APJ Abdul Kalam
- B. Atal Behari Vajpeyi
- C. Indira Gandhi
- D. None of the above

3. From which year is the country observing the National Technology Day annually?

- A. 1998
- B. 1999
- C. 2000
- D. 2001

4. Which one of the following is not a Disruptive Technology?

- A. E-commerce
- B. Block Chain
- C. GPS systems
- D. Automobile

5. Which of the following is considered the biggest technological advancement of the 20th century?

- A. Nuclear energy
- B. Genetic Engineering
- C. Computers and Internet
- D. All of the above

6. The IoT (Internet of Things) and are the two latest technological advancements that are rapidly transforming human lives.

- A. Information and Communication Technology
- B. Spatial Computing
- C. Cloud Programming
- D. Hyperconnectivity

7. Who created the world's first digital camera in 1975?

- A. Steven Sasson of Eastman Kodak
- B. Steven Sasson of Fairchild Semiconductors
- C. Barry Wellman of Eastman Kodak
- D. Barry Wellman of Fairchild Semiconductors

8. Which of the following technologies had a short lifespan of less than a decade in India, unlike the West?

- A. VHS
- B. PDA
- C. Pagers
- D. Floppy Disk

9. Then Union Telecom minister Sukh Ram made the first mobile phone call in India on July 31, 1995. Who did he call?

- A. Then West Bengal Chief Minister Jyoti Basu

- B. Then Madhya Pradesh Chief Minister Digvijay Singh
- C. Then Andhra Pradesh Chief Minister NT Rama Rao
- D. Then Tamil Nadu Chief Minister J Jayalalitha

10. Which of the following is not true about internet penetration in India?

- A. More than 50% Indians are active users of the internet.
- B. Telangana is the leading state with internet penetration of 70%.
- C. Internet penetration is growing faster in rural India compared to urban areas.
- D. There are more users of the internet by numbers in rural India compared to urban India.



Getting Hyper About Hypertension

- May 17 is observed annually as the World Hypertension Day.
- It's a day designated and initiated by The World Hypertension League, an umbrella organization of 85 national hypertension societies and leagues.
- An estimated 1.28 billion adults aged 30–79 years worldwide have hypertension, most (two-thirds) living in low- and middle-income countries.
- An estimated 46% of adults with hypertension are unaware that they have the condition.

- Hypertension is a major cause of premature deaths worldwide.
- Hypertension (high blood pressure) is when the pressure in your blood vessels is too high (140/90 mmHg or higher). It is common but can be serious if not treated.
- People with high blood pressure may not feel symptoms. The only way to know is to get your blood pressure checked.
- Things that increase the risk of having high blood pressure include:

- older age, genetics, being overweight or obese, not being physically active, high-salt diet, too much alcohol.
- Lifestyle changes such as eating a healthy, low-salt diet, losing weight, being physically active, quitting tobacco can help lower blood pressure.
- An estimated 220 million adults in India suffer from hypertension.
- Mercifully, India does not figure in the list of top 10 countries with hypertension patients, neither for men, nor for women.

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

INDIA'S
LEADING NATIONAL
SCIENCE MAGAZINE

AUGUST 2021 VOL 19 ISSUE 65

www.scienceindiamag.in

PUBLISHED BY VIJNANA BHARATI

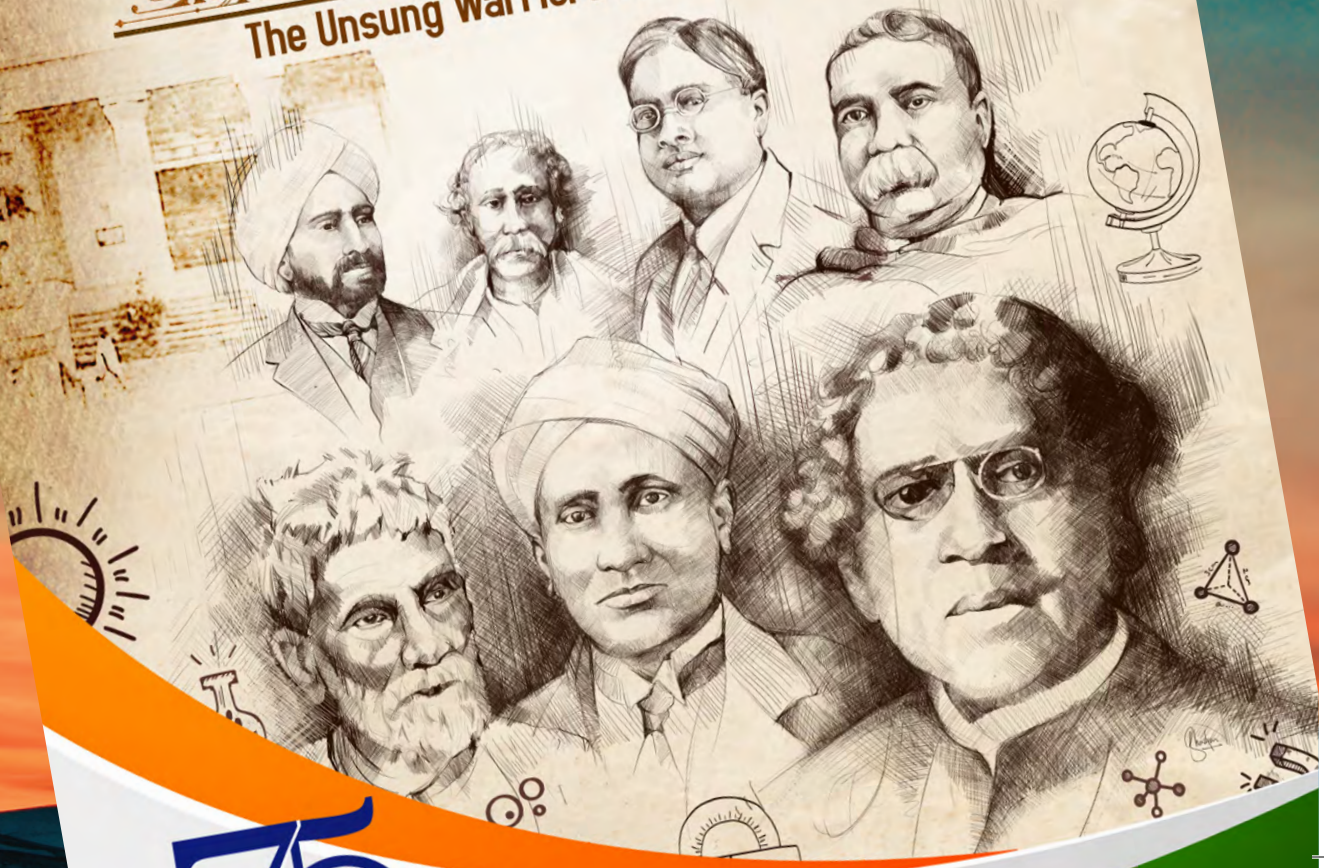

Science INDIA

राष्ट्रहिताय विश्वमङ्गलाय

Connecting science and people with an Indian perspective

COLLECTOR'S EDITION

The Unsung Warriors of Swatantrata





SUBSCRIPTION FORM

Mr Ms Dr Prof

Name of the Institution/Individual

Address

City State Pincode

Email Phone

Subscription Period : Mode of payment : Cash/Cheque/DD

Amount Rs (Rupees.....)

Cheque /DD No. Dated Bank

(Note: Cheque/DD is to be drawn favouring "Science India" payable at Delhi)

Please complete the order form and mail it to us at:

Science India,
C/o Vijnana Bharati
A - 4, First Floor,
Gulmohar Park
New Delhi - 110049
Tel: 011- 47597224 / 011- 41040846

Online subscription facility is
available at www.vibhaindia.org/register/publications

NEFT/RTGS details for online transfer:

Name of the Bank : Indian Bank
Account Name : SCIENCE INDIA
Bank A/c No : 6921352953
Type of A/c : Current
Bank Branch : Defence Colony
IFSC Code : IDIB000D008
MICR Code : 110019003

Sl. No.	Subscription Period	Subscription Type	Subscription Fees		
			India (Rs)	Foreign Countries	Digital Edition (Rs)
01	Single Issue	School Students	30	\$8	30
02	1 Year	School Students	300	\$80	300
		School Library	600		
		Colleges/Other Institutions/ Individuals	1,000		
03	2 Years	School Students	550	\$150	550
		School Library	1,000		
		Colleges/Other Institutions/ Individuals	1,750		
04	3 Years	School Students	800	\$210	800
		School Library	1,500		
		Colleges/Other Institutions/ Individuals	2,500		

Mudumbai Seshachalu Narasimhan

(7 June 1932 – 15 May 2021)

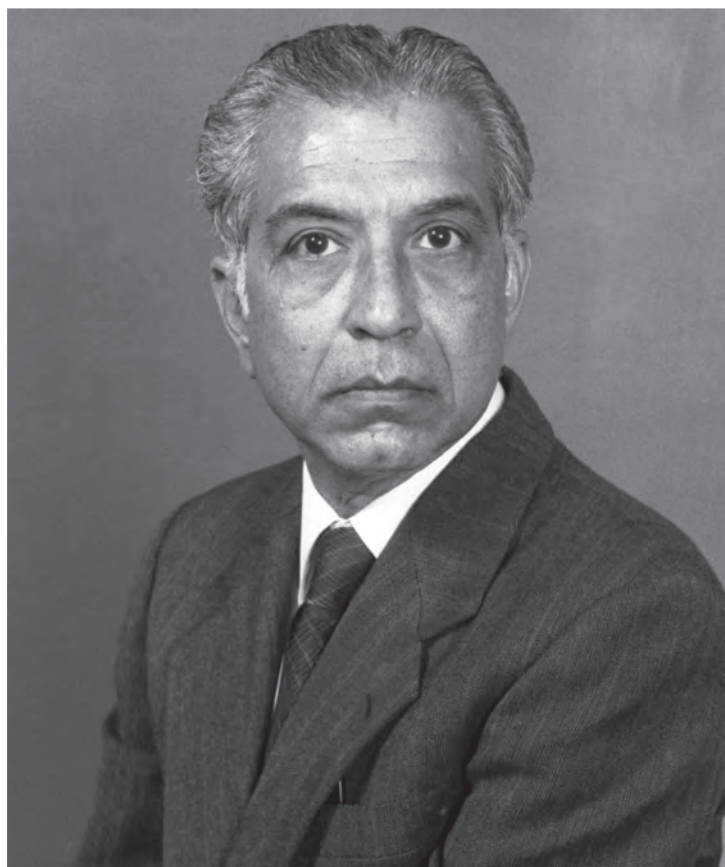


Image Courtesy: Wikimedia Commons

Acclaimed mathematician MS Narasimhan, who received the Padma Bhushan in 1990, is the only Indian to win the King Faisal International Prize in science. A recipient of the prestigious Shanti Swarup Bhatnagar Prize in 1975, he is known for his work in number theory, algebraic theory and partial differential equations, among others.

Celebrating Science This Month

MAY 3

I Bhooshana Rao, the founding president of the Indian Academy of Forensic Medicine, passed away in 1976.

MAY 5

CARTOSAT-1 satellite, the first Indian Remote Sensing Satellite capable of providing in-orbit stereo images, was launched in 2009.

MAY 6

INS Vela, the fourth submarine of the first batch of six Kalvari-class submarines for the Indian Navy, was launched in 2019.

International No Diet Day.

MAY 8

World Thalassaemia Day is observed annually to raise awareness about this genetic disease in which the body's ability to produce haemoglobin and red blood cells is affected.

MAY 9

NV Madhusudana, physicist known for his research on liquid crystals, was born in 1944.

MAY 11

National Technology Day. Read more about it in the Quiz section.

MAY 12

International Nurses Day.

Pramatha Nath Bose, credited with the setting

up of the first soap factory in India, was born in 1855. He played a major role in the establishment of Tata Iron and Steel Company, Jamshedpur.

The Indian Academy of Forensic Medicine (IAFM), located in Bambolim, Goa, was founded in 1972.

MAY 15

Prod MS Narasimhan, first chairman of National Board for Higher Mathematics, died in 2021.

MAY 16

International Day of Light is observed each year to mark the anniversary of the first successful operation of the laser in 1960.

MAY 17

World Hypertension Day.

World Telecommunication Day is celebrated to raise awareness of the possibilities of Internet and other information and communication technologies (ICT).

Indian mathematician Radhanath Sikdar, the first person to calculate the height of Mount Everest in 1852, passed away in 1870.

MAY 18

World AIDS Vaccine Day.

India's first successful nuclear test, codenamed Smiling Buddha, was conducted in 1974.

Space scientist Venkataraman Radhakrishnan was born in 1929. Son of Nobel laureate Sir CV Raman, he was a member of the Royal Swedish Academy of Sciences and served as Director of Raman Research Institute, Bengaluru.

MAY 19

INS Kavaratti, an anti-submarine warfare corvette of the Indian Navy, was launched in 2015.

Jamsetji Tata, father of the Indian industry and founder the Tata group, India's biggest conglomerate, passed away in 1904.

MAY 20

SROSS-C, the first satellite successfully orbited by ASLV, was launched in 1992.

MAY 22

International Day for Biological Diversity.

MAY 23

World Turtle Day.

Prahalad Chunnilal Vaidya, an Indian physicist and mathematician, renowned for his instrumental work in the general theory of relativity, was born in 1918.

MAY 25

Ashutosh Mukherjee, the first student to be awarded a dual degree (MA in Mathematics and MSc in Physics) from Calcutta

University, passed away in 1924. He laid the foundation of Bengal Technical Institute in 1906 (later Jadavpur University), and University College of Science (Rajabazar Science College) in Calcutta, 1914.

MAY 26

IRS-P4 (OCEANSAT), the first satellite primarily built for ocean applications, was launched in 1999.

Agronomist Benjamin Peary Pal was born in 1906. He was the first DG of Indian Council of Agricultural Research and director of Indian Agricultural Research Institute.

MAY 27

Indian Institute of Science set up in Bangalore, 1909.

MAY 28

Physicist Shivaramakrishnan Pancharatnam, who worked under Sir CV Raman's guidance, passed away in 1969.

The *Nature* magazine in May 1896 published a paper by Acharya PC Ray on mercurous nitrite, which laid the foundation of the first research school of modern chemistry in India.

MAY 31

World No Tobacco Day.

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



Powering Positive Transformation for
PEOPLE. PLANET. PLANT.

Dalmia Bharat Limited is committed to be an aware and effective corporate citizen.

We take our social responsibility as an opportunity to be a partner in the sustainable development of our stakeholders.



TEAM VVM IS INVITING YOU
TO JOIN US LIVE ON



<https://www.youtube.com/@VidyarthiVigyanManthan>

INAUGURAL NLC 2023-24
09:00 AM ONWARDS

MAY
18

VALEDICTORY NLC 2023-24
04:00 PM ONWARDS

MAY
19

LAUNCH OF VVM 2024-25
04:00 PM ONWARDS

MAY
19

Registration starts at - <https://vvm.org.in>

- ALL EVENTS WILL BE LIVE FROM -

**INDIAN INSTITUTE OF SCIENCE EDUCATION
AND RESEARCH BHOPAL (IISER BHOPAL)
BHOPAL, MADHYA PRADESH**



VIJNANA BHARATI

Organiser



NCSM

Organiser



एन सी ई आर टी
NCERT

Organiser



IISER BHOPAL

Host Institute