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Science INDIA

राष्ट्रहिताय विश्वमङ्गलाय

Connecting science and people with an Indian perspective

CRYPTOLOGY
SAFEGUARDING INFORMATION HIGHWAY

- 9TH INDIA INTERNATIONAL SCIENCE FESTIVAL GOES TO FARIDABAD
- IFS, BUTS & PLEDGES REAFFIRMED AT COP28 IN DUBAI
- SIGNIFICANCE OF IPR IN A COUNTRY WITH ANCIENT SCIENTIFIC KNOWLEGE

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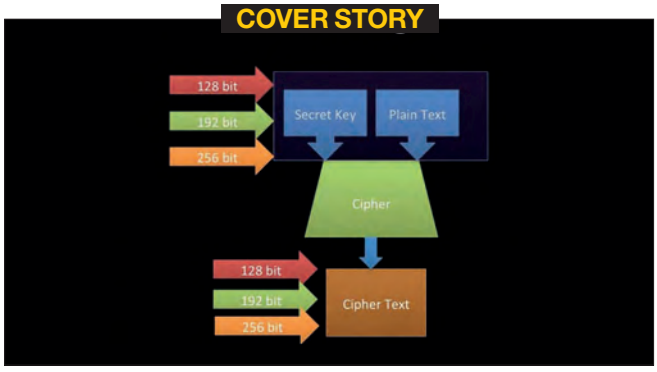
What's Inside



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INDIA INTERNATIONAL SCIENCE FESTIVAL (IISF) 2023

With the theme 'Science and Technology Public Outreach in Amrit Kaal', the ninth edition of the India International Science Festival (IISF) 2023 — the country's largest spectacle in the field of science and technology — will be held at Faridabad from 17 to 20 January, 2024.

ORGANISER: Organised jointly by Government of India, Government of Haryana and Vijnana Bharati
VENUE: Translational Health Science and Technology Institute (THSTI) and the Regional Centre for Biotechnology, NCR Biotech Science Cluster, 3rd Milestone, Faridabad-Gurugram Expressway, Faridabad, Haryana
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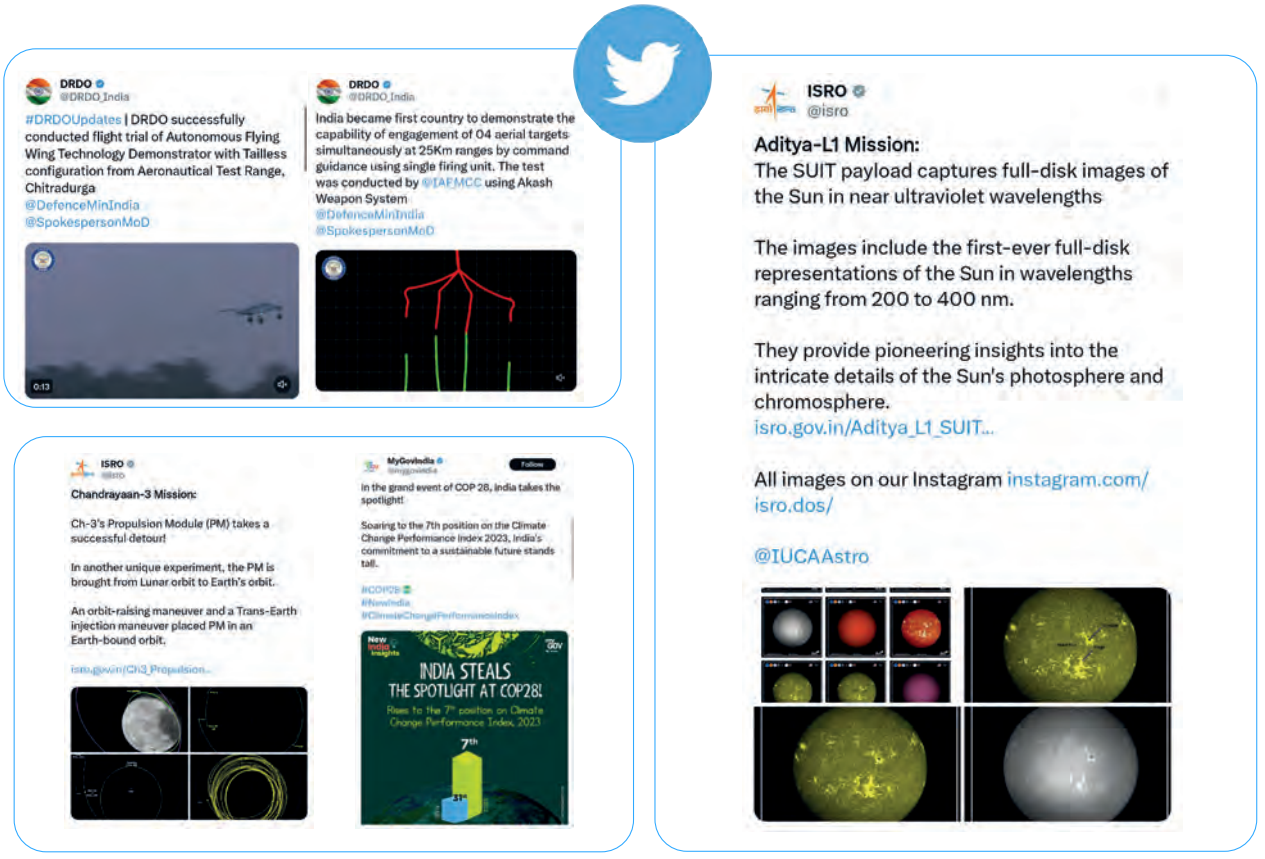

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Let's Connect

Dear Readers,
As the year comes to a close, the country can truly look back in pride upon the scientific accomplishments we achieved as a nation, to add heft to our increasing weight globally — a pole position that we are truly set to reclaim in not so distant a future.

These scientific achievements are a pointer to several great things taking place in the country right now — the immense intelligence of our scientific community, the will of the government to go out and support them, the enthusiasm of the people to join the science movement, and the widespread reach of science to every nook and corner of the country. This is the result of sustained, collective effort of the nation, which we need to celebrate.

One such celebration has been taking place annually since 2015, the India International Science Festival (IISF), whose ninth edition will be held in the new year, from January 17 to 20, in Faridabad. Born as a result of collaborative effort between the Ministry of Science and Technology, Ministry of Earth Sciences and Vijnana Bharati, this festival is a salute to science and the intention to include every single Indian in the fold of science. The edition carries details of the festival and its numerous components, which we urge the readers of *Science India* to participate in with fervour and become a part of the ever-expanding science movement of the country.

Our cover story this edition is on Cryptography, which we hope will pique the interest of all those of us who want to know more about how our digital lives are kept secure. It's interesting that cryptography as a science dates back to nearly 4000 years though it has evolved tremendously in the centuries thereafter, to become the mainstay of our contemporary digital reality. We don't even realise how embedded we are in the digital world, and how vital it is to keep it secure.

We have another story that deals with security — that of intellectual property rights, and how and why should they be protected. It is of special significance to a country like India that has an unparalleled rich ancient heritage of scientific knowledge that Indians use in their day-to-day lives, yet others have tried to misappropriate this wealth, by daring to patent it in their exclusive name. The case of the US patent on medicinal values of turmeric in the 1990s is still fresh in our minds and how it woke us up to protect our ancient wealth.

The biggest need for protection, however, is that of our mother earth that has been used and abused for centuries by humans to have reached a point of total environmental collapse. The world leaders congregated in Dubai under UAE's presidency to deliberate on the multifarious topic of climate change under COP28, where, a lot was said, a lot was intended, but not much was achieved. Read on about the exact deliberations at the conference, what it concluded and what it means for India.

As we look forward to attend the upcoming IISF, we hope to come back enriched in our knowledge of science in India and Bharatiya science, and share insights with our readers through bouquets of great stories the whole of the new year coming up.

This edition carries details of the upcoming ninth India International Science Festival in Faridabad, January 17-20, which we urge the readers of *Science India* to wholeheartedly participate in

9TH IISF / 17-20 JANUARY 2024, FARIDABAD

Unleashing the Wonders of Science: Exploring India International Science Festival

The ninth edition of the festival aligns itself with Prime Minister Narendra Modi's vision of harnessing S&T's power for national prosperity

■ Dr Arvind C Ranade

Image Courtesy: IISF

Above: Mega Science Technology & Industry Expo at IISF 2021 in Panaji; Right: A young science enthusiast at IISF 2022 in Bhopal

Science isn't just for scientists—it's for everyone. Science has long been the harbinger of innovation and progress, shaping the world we live in today. It is the realm of wonders and possibilities that shapes our world, from the gadgets we use daily to the exploration of distant planets. To realise and explore the magnificence of the scientific world, let us get immersed into the 9th edition of the India International Science Festival (IISF) from 17th to 20th January 2024 at the combined campus of Translational Health Science and Technology Institute and Regional Centre for Biotechnology at NCR Biotech Science Cluster, Faridabad.

Under the visionary leadership of Prime Minister Narendra Modi, India has embarked on a transformative journey in Science and Technology (S&T). The roadmap for 2047 reflects a resolution to harness S&T for national prosperity. Towards this sacred mission, the India International Science Festival (IISF) is a celebration to open the doors of science to all, inviting us to marvel at its beauty, understand its complexities, and dream of its endless possibilities. It stands as a testament to the celebration of scientific exploration, fostering a culture of curiosity, and inspiring the next generation of innovators.

JOURNEY OF IISF

The journey of IISF is nothing short of remarkable. Through the collaborative efforts of the Ministry of Science and Technology, Ministry of Earth Sciences, and Vijnana Bharati, in the year 2015, IISF marked the beginning of an odyssey that has traversed through eight successful editions, each leaving an indelible mark on India's diverse landscape, from north to south and east to west, epitomizing a commitment to reaching every nook and corner of the nation. Even amidst the challenges posed by the COVID-19 pandemic, when the world faced adversity, IISF displayed resilience by seamlessly transitioning to virtual

platforms, ensuring uninterrupted scientific engagement and knowledge dissemination and that the spirit of scientific exploration continued undeterred. Lately, in the year 2021, the Department of Atomic Energy and the Department of Space joined hands in strengthening India's scientific temperament through this festival.

This year IISF is taking place at Faridabad in the state of Haryana, while the Government of Haryana is providing privileged support for the smooth and successful conduct of this mega science festival.

THE HEARTBEAT OF IISF

The theme of this edition of IISF is 'Science and Technology Public Outreach in Amrit Kaal'. Through a diverse array of programs and initiatives tailored for everyone, IISF 2023 is ensuring the dissemination of scientific knowledge and India's scientific achievements to the general populace. For instance, the event Student Science Village offers a vibrant platform for budding young minds hailing from far-flung areas of India to delve into hands-on experiments, interact with scientists, and unravel the mysteries of the scientific world. From Face-to-Face sessions with pioneers in various scientific fields fostering inspiration and mentorship to exploring science through Games and Toys that bridge the gap between education and entertainment, leveraging play to instil a love for STEM subjects in children, IISF beautifully creates a playground of learning that is joyful, fun and enlightening.

At the heart of IISF lies a mission to ignite the flames of innovation. The Students Innovation Festival – Space Hackathon challenges young enthusiasts to solve the complexities of space expeditions. In this way, the festival exposes the next generation to real-world problems and tinkers with the innovativity of young beautiful minds.

Vigyanika – Science Literature Festival takes us on a journey through magical words and imagination, where the pages of science come alive celebrating the fusion of science and creativity, featuring keynote lectures, panel discussions, workshops, and competitions. It is a celebration of India's strides in science and a platform to spark conversations that bridge the gap between science and society. The festival's commitment to nurturing budding scientists and teachers is evident in initiatives like the Young Scientists' Conference, and the Education for Aspiring India – National Science Teachers Workshop. These platforms provide invaluable opportunities for young minds to showcase innovations, exchange ideas, and chart the course for India's scientific future.

With a myriad of events, the festival serves as a convergence point for diverse stakeholders in the S&T landscape. The event New Age Technologies Show ensures the enlightenment of the people with the current technological advancements in different scientific fields whereas S&T Media and Communicators Conclave acts as a forum to foster dialogue, disseminate scientific knowledge, and propel India's scientific vision to the forefront. Events like the National Social Organizations and Institutions Meet (NSOIM), the State S & T Ministers and Center and States S & T Secretaries Conclave, and the Start-up, Technology, and Innovation B2B Meet facilitate discussions, promote partnerships, and synchronize efforts for holistic progress in science and technology.

The Guinness World Record of previous IISF editions has been dropped this year. Instead, the festival has introduced the IISF challenge to pursue the young minds to accept challenges and achieve new milestones.

The festival isn't just about test tubes and equations; it is about inclusivity. It celebrates the rich tapestry of India's cultural heritage through a vibrant Cultural Programme — a showcase of music, dance, and art that embodies the essence of unity in diversity.

THE IMPACT OF IISF

Beyond the realms of programs and initiatives, IISF transcends into impacting society at large. Its inclusive approach ensures representation from all strata of society, promoting scientific temperament among the masses. It fosters a culture of scientific curiosity, encouraging critical thinking, and nurturing a spirit of innovation among the youth, inspires the next generation of innovators, and encourages us to look at the world through the lens of science. It's not just about learning formulas but understanding the marvels that shape our lives. IISF sparks conversations, nurtures talent, and fuels our imagination for a brighter, technologically advanced future.

THE IISF LEGACY

The India International Science Festival stands as a testament to the power of scientific exploration and innovation. Its evolution, from inception to its current stature, highlights India's commitment to nurturing a culture of scientific inquiry and technological advancement. The cumulative impact of IISF resonates through its multifaceted initiatives. It has become a pivotal platform for showcasing India's scientific achievements, stimulating collaborations, and inspiring a new generation of scientists and innovators. By providing a stage for interaction between scientists, policymakers, technocrats, educators, and the public, IISF continues to shape India's scientific trajectory.

THE FINAL WORD

The India International Science Festival isn't merely an event; it's a celebration of human ingenuity, a testament to our insatiable quest for knowledge. Its an invitation for all of us — regardless of age, background, or profession — to join hands, explore, and embrace the wonders of science.

As we step into the world of IISF, we are not just spectators; we are explorers, dreamers, and contributors to the magnificent world of science that shapes our tomorrow. So, let us immerse ourselves in this carnival of curiosity, for in the journey of discovering science, we discover ourselves.

**The writer is Director, National Innovation Foundation-India, Ahmedabad, and National Chief Coordinator for India International Science Festival (IISF) 2023.*

Uttarakhand Chief Minister Pushkar Singh Dhami cinches one of the construction workers after rescue from the collapsed Silkyara tunnel

A Frightening Tunnel Collapse and a Miracle Rescue

The fragile nature of Himalayan geology cannot be overemphasised, which the mighty mountains underscore with unfailing regularity through disasters such as the Silkyara tunnel collapse

■ **Dr Amit Kumar Verma and Amit Jaiswal**

The Silkyara-Barkot tunnel is a crucial component of the ambitious Char Dham all-weather road project initiated by the Central Government. Spanning 4.5 km between Silkyara and Dandalgaon, it is a vital segment of the Brahmakhal-Yamunotri section. Unfortunately, what was intended to enhance connectivity among the four significant pilgrimage sites known as Char Dham — Kedarnath, Badrinath, Yamunotri, and Gangotri — through an extensive 889-kilometer road network, became a site of tragedy when a section of the tunnel collapsed on November 12.

The construction of the tunnel was entrusted to the Hyderabad-based Navayuga Engineering Company by the National Highways and Infrastructure Development Corporation Ltd (NHIDCL), a fully-owned company of the

Image Courtesy: PIB

Ministry of Road Transport & Highways, Government of India.

GEOLOGICAL CHALLENGES IN THE HIMALAYAS

Since the tunnel's commencement in December 2016, geological challenges have surpassed initial predictions, confirming findings from supplementary exploration measures conducted at the project's initiation. Controversies have marred the venture, with environmentalists expressing concerns about the potential detrimental impacts of extensive drilling and construction undertakings. Worries include the possibilities of subsidence, landslides, and significant environmental degradation in the ecologically sensitive Himalayan region.

The Himalayas, a geological marvel, is the youngest and highest range of fold mountains globally, originating around 40-50 million years ago. Characterized by high seismic activity, it experiences continuous growth from the ongoing collision between the Indian and Eurasian tectonic plates. The Silkyara tunnel is situated within the lesser physiographic zones, close to the main central thrust of the Himalayas, a major geological fault (zone of fractures). The tunnel traverses highly sheared and extensively deformed lithology, including metasedimentary rocks such as phyllite, slate, and metasiltstone. Quartz veins, ranging from less than 2 cm to 10 cm in thickness, traverse the country rock primarily along the foliation plane. The hill slope, with an angle between 50°-60°, is covered with overburden supporting moderate vegetation, predominantly evergreen pine trees. The outcrop is concealed beneath approximately 3m of weathered slope wash materials. Research indicates that topsoil erosion in the Himalayas occurs at a rate three times higher than the national average, suggesting a structurally vulnerable region due to fractured and fragile rocks with numerous joints. The diverse rock types in this area pose a challenge, contributing to the inherent instability of the region.

Research indicates that topsoil erosion in the Himalayas occurs at a rate three times higher than the national average, suggesting structural vulnerability

RESCUE OPERATION IN DELICATE GEOLOGY

The proposed Silkyara-Barkot tunnel encounters rocks with inherent weakness, necessitating a robust support structure. Based on surface geological assessments, it is anticipated that the encountered rock types along the diversion tunnels will comprise 20% good (Class 2), 50% fair (Class 3), 15% poor (Class 4), and 15% very poor (Class 4), as outlined in the report.

On November 12, Silkyara tunnel collapsed, trapping 41 workers. Operation Zindagi (life) was launched by the Uttarakhand state government to rescue the trapped workers. Rescuers needed to dig through 59m of collapsed debris to excavate the trapped workers. To expedite the rescue process, first horizontal drilling machine to install an 800mm escape pipe was deployed. Then, advice was sought from experts who had successfully saved students in the Tham Luang cave incident in Thailand in 2018.

Cracking noises reported on November 17 prompted the suspension of drilling. Alternative access tunnels were started parallel and adjacent to the existing main tunnel. Three pipes were bored: one for oxygen, one for food transit, and a 15-cm-wide conduit for hot meal delivery and endoscopic camera insertion. The Border Roads Organisation built a 1.15-kilometer (0.71-mile) road to a position on a hillside above the tunnel on November 19 while preparations were underway to dig a vertical shaft to facilitate rescue. Drilling was delayed on November 22 and 23 as major repairs were required on the drilling machine.

At this point, it was thought that the operations had progressed approximately 75% of the way through the obstructing debris. After successfully digging 47 metres (154 feet) down the tunnel, the tunnel drilling machine failed and became trapped within, hence impeding the progress of the drilling and posing another challenge to the rescue mission on November 25.

In order to cut through the rubble and get to the trapped workers, the rescue team opted to clear the final muck of approximately 12m manually. Drilling was stopped around nine metres (30 feet) short of breaking through. Arnold Dix, an Australian tunnelling expert who was involved in the rescue attempt, also advised the rescue team to proceed with caution. Different techniques to gain access to the workers were intensified on 27 November. At the Silkyara end, Satluj Jal Vidyut Nigam's vertical drilling reached a depth of 32 metres (105 feet), and Rail Vikas Nigam was laying a third pipeline to supply workers with requirements. While Oil and Natural Gas Corporation (ONGC) was getting ready for vertical drilling, Tehri Hydro Development Corporation Limited (THDC) India Limited successfully completed a drill on the Barkot end of the tunnel that reached a depth of 12 metres (39 feet).

On November 28, the rescue team called 'rat-hole' miners who managed to smash through the last section of debris and manually push a pipe to the workers who were trapped. Over the course of 17 day, the rescue crew evacuated every worker individually on stretchers.

Dix, after the course of the long-drawn operation, said the successful rescue of the trapped workers was a 'miracle'. Dix was also seen praying for the safe evacuation of the trapped workers in Uttarakhand. He also said in an interview that the Silkyara tunnel rescue operation was like an epic wherein the mountain was controlling everything. "It's like an epic from 3000 years!"

**Dr Amit Kumar Verma is Associate Professor and HoD, Civil and Environmental Engineering, IIT Patna, where Amit Jaiswal is a PhD scholar. Dr Verma is a recipient of several prestigious awards.*

SCIENCE DIPLOMACY

COP28 Reality Check: Reaffirming Yet Deferring Environmental Ambitions

All images courtesy: PIB

As pundits undertake threadbare analysis of the outcomes of COP28, spotlight should also be trained on the role terrorism has come to play in thwarting global community's best intentions on climate change

Above: World leaders at the 28th Conference of Parties (COP28), Dubai, United Arab Emirates. Representatives from 197 countries showcased their efforts to limit global warming and held discussions to prepare for future climate change

■ **Uday Kumar Varma**

As the sun rose on the arid Dubai sky on the morning of December 13, COP28 concluded approving a deal on transition away from fossil fuels. That transition would be in a way that gets the world to net zero greenhouse gas emissions in 2050 and follows the dictates of climate science. Called a global stocktake and arrived at after bitter and often angry haggling over the proposed draft agreement the whole of the previous night, it was one of the tamest expressions of world resolve to deal with environmental issues.

"It is a plan that is led by the science," Sultan al-Jaber, the President of the Conference declared. "It is an enhanced, balanced but make no mistake, a historic package to accelerate climate action. It is the UAE consensus." "We have language on fossil fuel in our final agreement for the first time ever," al-Jaber, further added. Words that may comfort but betray most expectations.

The new proposal doesn't go so far as to seek a "phase-out" of fossil fuels, which more than 100 nations had pleaded for. Instead, it calls for "transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner, accelerating action in this critical decade."

The Alliance of Small Island States said in a statement that the text "is incremental and not transformational. We see a litany of loopholes in this text that are a major concern to us."

Many nations have criticised the agreement for failing to call for a "phase-out" of fossil fuels, which scientists say are by far the biggest source of the greenhouse gas emissions driving global warming. More than 100 countries ranging from the United States

and the EU to tiny island nations had pushed for the language, but came up against strong resistance from members of the OPEC oil producer group and its allies.

Shorn of semantics, the agreement is at best a fig leaf, exposing deep fissures among the divided world community. Predictably COP28 has ended as yet another elaborate exercise of the world community crying hoarse on the problem but pussy footing when action is called for. Clearly immediate concerns fuelled by self-interest and perpetuation of an established order, dominated over long term global interests. It was a continuation of a pattern and tradition; but COP28 has been particularly dismal in outcomes. As the Chinese representative so eloquently expressed, it has been the most difficult conference in recent years. Even the presidency admitted that this conference will be best remembered for the divergence in opinions than for agreements.

A POSITIVE BEGINNING

Although on the very first day of COP 28, a major breakthrough brightened the prospects for a conference that was widely feared to be a wash out, the challenges before it were formidable and intractable. But the fact that the diplomats from nearly 200 countries approved a plan for a 'loss and damage' fund, a demand developing countries have been making for over three decades, lifted the mood and set an upbeat tone.

The pledges to this fund, as of now, add up to $549 million, with UAE and Germany contributing $100 million each while UK pledging about $75 million and Japan $10 million. The US committed a disappointing $17.5 million that many feel was niggardly from the largest economy and compared to the damage it has caused. The fund will help vulnerable countries hit by climate disasters, which are made worse by pollution spewed by wealthy nations. The adequacy of the funds may be judged by the fact that climate-related damages are expected to cost developing countries between $280 billion and $580 billion per year by 2030.

UNFCCC REPORTS: EVALUATING GLOBAL CLIMATE TRAJECTORY

The UNFCCC Secretariat, just before the Conference, published two synthesis reports on Nationally Determined Contributions (NDCs) and long-term low-emission development strategies (LT-LEDS) under the Paris Agreement. These reports, crucial for COP 28 in Dubai, revealed that despite increased efforts by some countries, urgent action was required to alter the global emissions trajectory and mitigate the impacts of climate change.

The first report, 'Nationally Determined Contributions Under the Paris Agreement,' analyzed the latest NDCs from 195 parties, indicating that while emissions in 2030 are projected to be 2% below 2019 levels, they lack the necessary rapid downward trend. Achieving emission peaking before 2030 depends on implementing the conditional elements of NDCs, contingent on enhanced financial resources, technology transfer, and capacity-building support.

The second report focused on LT-LEDS, incorporating submissions from 75 parties representing 87% of the world's GDP, 68% of the global population in 2019, and about 77% of global greenhouse gas emissions in 2019. Despite a significant portion targeting net-zero emissions, many net-zero targets remain uncertain and defer critical actions to the future. The overall assessment post-COP 27 was predicted as pessimistic, with the ongoing Middle East crisis further clouding prospects. Even before the Conference began, doubts were expressed about any significant outcomes. Many felt that the potential failure of this event was seeded in terrorist attacks across the world by groups prioritizing hatred and violence over environmental concerns.

COP28 has taken place under the dark shadows of the crisis in the Middle East, the Hamas-Israel conflict, and the Russo-Ukraine war

Prime Minister Narendra Modi at the COP28 session, 'Transforming Climate Finance' in Dubai

The task, therefore, in Dubai was both formidable and fractious.

INDIA AT COP28

India did make its presence felt at Dubai. The most dramatic, of course, was the storming of the stage by Licypriya Kangujam, a 12-year-old climate-justice activist from India. She rushed onto the stage at the COP28 climate summit on Monday, holding a sign above her head that read: "End fossil fuels. Save our planet and our future." Kangujam, founder of The Child Movement has been active since she was six years old. She was later escorted away as the audience clapped. Her appearance briefly electrified the atmosphere.

Prime Minister Narendra Modi's presence at the beginning of the confer-

ence underlined the priority and urgency India accords to the issues of environment. On 1st December, Modi addressed the opening session of COP 28, and proposed to host COP 33 Summit in India in 2028. On the sidelines of COP 28 in Dubai, Modi launched LeadIT 2.0, with a focus on inclusive and just industry transition. He added that LeadIT 2.0 focused on co-development and transfer of low-carbon technology and financial assistance to emerging economies. Earlier, addressing a session on Transforming Climate Finance, Modi urged developed countries to completely reduce carbon footprint intensity by 2050.

The Environment Minister Bhupendra Yadav invoked Prime Minister Modi's earlier call for LiFE-Life Style for Environment, further stating that equity and climate justice must be the basis of global climate action. This can be ensured only when the developed countries take the lead in ambitious climate action. He also recounted the initiatives taken by India on augmenting non-fossil fuel energy sources. "India's contribution to climate action has been significant through its international efforts such as International Solar Alliance (ISA), Coalition for Disaster Resilient Infrastructure (CDRI), creation of LeadIT, Infrastructure for Resilient Island States (IRIS) and the Big Cat Alliance," he said. The Global Biofuel Alliance, launched when the G20 leaders met in New Delhi earlier this year, seeks to serve as a catalytic platform fostering global collaboration for advancement and widespread adoption of biofuels, he added.

ROLE OF TERRORISM: MISSING PIECE IN GLOBAL DISCOURSE

COP28 could not have taken place at a more inopportune time. The world's attention riveted to Middle East in the wake of Hamas-Israel conflict, poised to escalate into a widespread crisis of extraordinary proportions, diminished the attention and intensity of discussions in Dubai. Undoubtedly COP28 has happened under the dark shadows of the crisis in the Middle East, the Hamas-Israel conflict, and the Russo-Ukraine war. The world is still at an edge hoping to obviate a global conflagration. The Middle East crisis is clearly created by the barbaric and reprehensible terrorist attack by Hamas. Terrorism, thus, casts a shadow on all endeavours of global co-operation, including COP.

Terrorism has never been discussed as a factor that affects obtaining progress on Global Environmental Goals. This omission seems both glaring and shocking in the background of terrorist activities across the globe duly and defiantly supported and financed by nations that must play a crucial role in achieving mitigated carbon emissions. For instance, many of the fossil fuel producing nations whose commitments are crucial in achieving any progress openly harbour terrorist organisations on their soil; and support and fund terrorist organisation in their own country and based on foreign soils. Terrorism requires all the natural resources that we are seeking to conserve. The economy of many of these countries is entirely dependent on producing fossil fuels. Terrorism leads to increased demand of these resources and those supporting terrorism act clearly in defiance and opposition of the global intent, rather hypocritically trumpeted by the same countries who openly work against them.

SEVEN ARGUMENTS LINKING TERRORISM TO ENVIRONMENTAL RISKS

Arguably, terrorism may not directly cause environmental degradation, but it poses significant risks to environmental sustainability. Here are seven key arguments highlighting the link between terrorism and environmental threats:

1. **Resource Diversion:** Counterterrorism efforts demand substantial resources, diverting attention and funding away from environmental initiatives, hindering sustainable practices and green technology development.

2. **Political Instability:** Terrorism induces political instability, disrupting governance and policy-making. This instability challenges the establishment and enforcement of environmental regulations, as governments prioritise security

All Images Courtesy: PIB

PM Modi voiced the concerns of the Global South at COP28 in Dubai

over environmental protection.

3. **Infrastructure Damage:** Acts of terrorism cause physical harm to critical infrastructure, such as energy facilities and transportation systems. Reconstruction may prioritize functionality over environmentally friendly practices, leading to increased emissions and pollution.

4. **Global Cooperation Disruption:** Terrorism strains international relations, hampering global cooperation on environmental agreements. Diplomatic efforts are disrupted, hindering the development of effective global solutions to climate change.

5. **Economic Impact:** Terrorism has severe economic consequences, diverting attention and resources from green technologies. Economic downturns lead to reduced investment in sustainable practices as immediate financial concerns take precedence.

6. **Migration and Resource Scarcity:** Terrorism-induced forced migration increases pressure on resources in host regions, potentially worsening environmental degradation. Competition for scarce resources may result in unsustainable exploitation of natural habitats and increased carbon emissions.

7. **Security Risks from Climate Change:** Climate change contributes to security risks, such as resource scarcity and extreme weather events. These challenges create conditions conducive to terrorism and conflict, forming a feedback loop between environmental issues and security concerns.

THE NEED FOR GLOBAL ACKNOWLEDGMENT

The lessons from the disappointing outcomes of COP28 must make us think why terrorism should not be brought on board as a factor and instrument of impeding environmental security of the globe and to deal with it accordingly. Given the geo-political compulsions and polarisation, the move shall surely be challenged and opposed, even berated. But it will be to the peril of the globe, to push it under the carpet. Recognizing terrorism's role in impeding environmental insecurity is crucial. Policymakers must acknowledge its impact to foster global stability, cooperation, and resilient infrastructure for simultaneous progress in security and sustainability goals. Ignoring terrorism's role risks undermining meaningful environmental progress.

It may be seeking a tall order. And the prevailing atmosphere of hostility, revenge, distrust, conceit and self-preservation does cloud a reasonable approach.

AN HONEST ASSESSMENT

In a letter of July 2023, the incoming UAE presidency of COP28 outlined four paradigm shifts for the summit: Fast-tracking the energy transition and cutting emissions before 2030, transforming climate finance, prioritizing nature and people in climate action, and aiming for the most inclusive COP ever. And as COP28 concludes, the first three shifts have at best seen limited progress, and the fourth still remains largely aspirational.

But there is an acknowledgement of the elephant in the room, as one of the ministers observed. Given the current world scenario, it is still a considerable achievement and gain. The reaffirmation of the world's environmental ambitions does find a strong expression, only it seems deferred for the present.

This may be a dark hour but isn't the night darkest before the dawn?

**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.*

Thick smoke from a road construction site in the foreground and from a factory in the background pollute early morning air in National Capital Region

Image Courtesy: Shutterstock

Air Pollution: The Invisible Health Threat

With more than 2 million deaths annually in India due to conditions caused by air pollution, mega cities such Delhi-NCR and Mumbai will need a paradigm change in thinking solutions to tackle the problem

Every day as we breathe in, an invisible storm of particles and molecules enters our bodies, endangering not just our lungs but also the rest of our body. Have you ever given careful thought to how crucial clean air is to your health and happiness? I think you must give this subject some thought because you probably belong to the 99% of individuals who are exposed to air pollution levels that are higher than advised.

Air pollution ranks just below high blood pressure, smoking, and diabetes as the leading risk factor for mortality

■ Prof Ram Sagar Misra

and a serious environmental threat. A modelling study published in *The British Medical Journal* (BMJ) stated that, there are 2.18 million premature deaths annually in India due to ischemic heart disease, stroke, chronic obstructive pulmonary disease and lung cancer, caused by air pollution from all sources. This number is just second to China. Air pollution, including asthma, is recognized as one of the main risk factors for non-communicable diseases having the potential to impact our whole body as well as cognitive and neurological impairment basically, way beyond our lungs.

Air pollution poses a threat to the public health economy as well. As per a report, air pollution ranks as the second most significant health risk in India, with an approximate annual economic cost of over 150 billion USD (Rs 15000

crore). This loss amounts to around 4% of India's GDP.

WHAT IS AIR POLLUTION?

A complex mixture of gases, liquid droplets, and solid particles make up air pollution. Different combinations of air pollution can originate from different sources. For example, air in a city gets polluted by dust from construction work, road dust, vehicular pollution, etc. In contrast, a rural area near a forest may have particulate matter consisting of soil, smoke from forest fires or open burning of waste.

Several air pollutants are measured, such as ozone (O3), nitrogen oxides (NOx), sulphur oxides (SOx), carbon monoxide (CO), and particulate matter PM2.5 and PM10 (particles with an aerodynamic diameter of equal to or less than 2.5, also called fine, and 10 micrometre respectively).

EFFECTS OF AIR POLLUTION ON HUMAN HEALTH

All major organs are impacted by fine particulate matter (PM2.5), which can enter the body through lungs and pass through the bloodstream. Chronic obstructive pulmonary disease (COPD), lung cancer, stroke, and other diseases of the cardiovascular and respiratory systems can be caused by exposure to PM2.5.

High levels of air pollution during pregnancy have also been linked to developmental delays by the time the child is three years old, as well as behavioural and psychological issues later in life, such as attention deficit hyperactivity disorder (ADHD), anxiety, and depression, according to recent research.

REDUCING AIR POLLUTION

Most sources of outdoor air pollution are well beyond the control of individuals and this demands concerted action by local, national and regional level policy-makers in various sectors.

There are many examples of successful policies that may reduce air pollution:

For industry: Clean technologies that reduce industrial smokestack emissions; improved management of urban and agricultural waste, including capture of methane gas emitted from waste sites as an alternative to incineration (for use as biogas);

For energy: Ensuring access to affordable clean household energy solutions for cooking, heating and lighting;

For transport: Shifting to clean modes of power generation; prioritizing rapid urban transit, walking and cycling networks in cities as well as rail interurban freight and passenger travel; shifting to cleaner heavy-duty diesel vehicles and low-emissions vehicles and fuels;

For urban planning: Improving the energy efficiency of buildings and making cities more green and compact;

For power generation: Increased use of low-emissions fuels and renewable combustion-free power sources (like solar, wind or hydropower); co-generation of heat and power; and distributed energy generation (e.g. mini-grids and rooftop solar power generation);

For municipal and agricultural waste management: Strategies for waste reduction, waste separation, recycling and reuse or waste reprocessing, as well as improved methods of biological waste management such as anaerobic waste digestion to produce biogas, are feasible, low-cost alternatives to the open incineration of solid waste, then combustion technologies with strict emission controls are critical; and

For health-care activities: Putting health services on a low-carbon development path can support more resilient and cost-efficient service delivery, along with reduced environmental health risks for patients, health workers and the community.

Image Courtesy: Wikimedia Commons

Vehicular pollution is a major cause of air pollution in urban areas. Here, a bus in Hyderabad emits thick smoke which is extremely harmful for health

GOVERNMENT INITIATIVES TO COMBAT AIR POLLUTION

Government has taken several initiatives to improve air quality. The following actions were initiated by the Union Government. Graded Response Action Plan (Delhi), Polluter Pay principle, Smog Tower, Tallest Air Purifier, National Clean Air Programme (NCAP), BS-VI vehicles, New Commission for Air Quality Management, Turbo Happy Seeder (THS) Air Quality and Weather, Forecasting and Research (SAFAR), Dashboard for Monitoring Air Quality, National Air Quality Index (AQI), Air (Prevention and Control of Pollution) Act, 1981, Pradhan Mantri Ujjwala Yojana (PMUY), etc.

Graded Response Action Plan

(GRAP), is being implemented through the Environment Pollution (Prevention & Control) Authority (EPCA), is a set of anti-air pollution measures implemented in Delhi-NCR. In 2020, the EPCA was replaced by the Commission for Air Quality Management (CAQM). In GRAP Stage 1 or Poor Stage, the AQI ranges from 201 to 300, Stage 2 or Very Poor from 301 to 400, Stage 3 or Severe Stage from 401 to 450, and in Stage 4 or Severe Plus above 450.

POLLUTION IN DELHI

Pollution level crosses the GRAP stage 4 and stage 2\3 in Delhi-NCR. The Punjab stubble burning emissions are what the AAP government would have you believe. However, the same government in Punjab fails to impose a ban on stubble burning. Other causes of pollution in the city are car emissions, construction and the burning of rubbish at waste plants.

Delhi also provides Mumbai and other cities a lesson in developing a comprehensive strategy as opposed to sector-specific initiatives. In the early 2000s, Delhi concentrated on lowering emissions from the transport sector, but at the same time, it permitted the expansion of polluting businesses and coal-fired power plants in the Delhi-National Capital Region (NCR) airshed. Within a 300-kilometer radius of Delhi, more than 75% of the operating capacity of coal-based power generation was added after 2007. Without sufficient emission control technologies, the unrestrained expansion of coal-based power generation capacity resulted in a significant rise in emissions. The growth of small and medium-sized businesses in Delhi-NCR added to the rising emissions. Rise in the use of private vehicles, unchecked industrial growth, and power generation without effective emission controls escalated air pollution.

POLLUTION IN MUMBAI

October is one of the most polluted months in Mumbai, when air pollution levels rise alarmingly. In certain regions of the city, the AQI surpassed even Delhi's values, at above 300. There has been a sharp rise in respiratory symptoms as a result of the pollution, especially in youngsters. The reasons seem unclear but ongoing construction projects are said to be significant. They reportedly occupy an area five times larger than Mumbai's commercial hub, Nariman Point. The construction of the metro, which has drastically reduced the width of important roadways like Dr DN Road renowned for its Art Deco structures, is another concern raised by environmental activists. Automobile pollution is further exacerbated by Mumbai's high private car density of 600 vehicles per kilometre of road.

The quality of the air in Mumbai is also impacted by climate change. Experts connected the 2022 La Nina, a climatic condition that blocked coastal breezes, to the elevated particle matter levels. The October heat and delayed monsoon retreat have made air pollution worse this year, even if there isn't a La Nina. Harish Phuleria, an associate professor from the Environmental Science and Engineering Department at IIT Bombay, suggests that a combination of outdoor pollution from vehicles and construction activities, along with certain meteorological phenomena, contribute to the problem. Dr Dilip Boralkar, an environmental consultant in Mumbai, believes that photochemical reactions, triggered by heat, have become a significant contributor to air pollution and smog in the past three years. According to some scientists, the efficiency of the sea breeze may be hampered by tall structures that produce localised wind patterns. Dr Harish Phuleria (IIT Bombay) contends that these patterns wouldn't be substantial enough to alter the weather throughout the city.

Delhi provides Mumbai and other cities of India a lesson in developing a comprehensive strategy as opposed to sector-specific initiatives

A ray of light has emerged for Mumbai with the recent announcements by MPCB, which include shutting down enterprises that pollute, and ordering Tata Power and Hindustan Petroleum Corporation Infrastructure Limited to cut operations by 50%. These actions point to a more coordinated strategy for Mumbai's air quality governance's emission management. However, unless mid- and long-term emission load reduction targets are made explicit in the state and local clean air action plans, these efforts might not last long.

The building and transport industries continue to be major contributors to high air pollution levels. It is indisputable that new development is necessary, but these industries also need stronger regulations and stringent enforcement. To avoid repeating the mistakes of Delhi-NCR, Mumbai must take the following steps:

1. Establish progressive emission reduction targets and emission load caps for all sectors of the city's economy that cause pollution, as well as the airshed that surrounds it.

2. To discourage the use of private vehicles, encourage the development of non-motorized and renewable energy-powered electric public transportation networks.

3. Instead of depending just on reactive strategies like smog guns and anti-smog towers, establish an air quality forecasting system for proactive efforts.

4. Free building sites of pollutants by enforcing pollution standards.

5. To increase responsibility for polluting industries and regulatory agencies, improve public data disclosure regarding emissions from all active industries in the airshed surrounding Mumbai.

With the ability to learn from Delhi's mistakes and take a comprehensive approach to decision-making, Mumbai might set the standard for sustainable development of clean air routes.

**The writer is Professor of Chemistry, School of Physical Sciences, Jawaharlal Nehru University, New Delhi.*

Rare Honour for Indian Scientist in Quantum Science Research

Prof Urbasi Sinha of Raman Research Institute becomes the first Indian to be appointed as Canada Excellence Research Chair in Photonic Quantum Science and Technologies

Science India Bureau

Prof Urbasi Sinha, a faculty member at the Quantum Information and Computing (QuIC) laboratory at Raman Research Institute (RRI) in Bengaluru, has been appointed as the Canada Excellence Research Chair (CERC) in Photonic Quantum Science and Technologies.

According to the Raman Research Institute, this is the first time an Indian scientist has received this esteemed accolade from the government of Canada.

Prof Sinha will receive an $8 million grant, fostering international collaborations in academia, industry, and other sectors over the next eight years. This substantial support aims to develop innovative lab-to-market models, propelling advancements in quantum technologies.

She specialises in pioneering research areas such as quantum communication, computation, optics, and fundamentals. Her laboratory has played a pivotal role in advancing secure quantum communications using satellites.

According to an official release, Prof Sinha is among 34 global scientists whose selection for the latest CERC was announced recently and her selection comes after a rigorous international peer-review process, emphasising her significant contributions to the field.

Prof Sinha heads the Quantum Information and Computing (QuIC) laboratory at RRI. This is one of the first labs in India to manufacture and establish the usage of entangled and heralded single photon sources towards various applications in quantum science and technologies. The current research areas include experimental secure quantum communications including quantum key distribution (QKD) in free space, fibre and integrated photonics, Quantum Teleportation as well as Device Independent random number generation; higher dimensional quantum information processing including photonic quantum computing; fundamental tests in quantum optics and quantum mechanics including generalized measurements and various studies based on static and dynamic properties of entanglement.

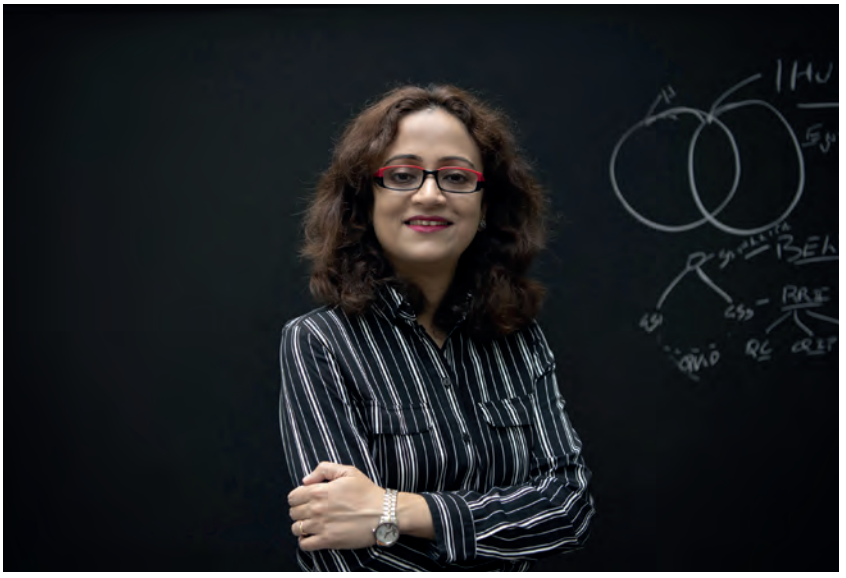

Image Courtesy: Twitter

Prof Urbasi Sinha heads the Quantum Information and Computing (QuIC) laboratory at Raman Research Institute, Bengaluru

One of the key projects being led by the lab is a collaboration between RRI and ISRO called 'Quantum Experiments with Satellite Technology', which is India's first funded project on satellite-based long distance quantum communications.

Presently affiliated with prestigious institutions in Canada, including the Institute for Quantum Computing and the University of Toronto, Prof Sinha's recognition underscores India's growing prominence in quantum science.

Sinha was born in London and completed her undergraduate and graduate degrees at the University of Cambridge. Her doctorate involved explorations of the Josephson effect. She moved to the Institute for Quantum Computing, Waterloo, Canada for her postdoctoral research, where she became interested in quantum computing and optics.

When Sinha shifted to Bengaluru, she was made a professor at RRI. She was named as one of Asia's Top 100 Scientists in 2018, appointed an Emmy Noether Fellow in 2020 and awarded the Chandrasekarendra Saraswathi National Eminence Award in 2023. Her husband, Prof Aninda Sinha, is a theoretical physicist working as a professor at the Center for High Energy Physics, Indian Institute of Science, Bengaluru.

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- Semiconductor Sensors and Micro-Systems Group
- Semiconductor Process Technology Group

Some of the Devices and Technologies Developed

- Accelerometer, Diamond Detectors, Sensor Interface Circuits, Gas Sensor Platform, Low Temperature Co-fired Ceramic Technology based Circuits, MEMS Hotplate, Silicon Carbide Schottky Diode Detectors, MEMS Ultrasonic Transducers, MEMS Acoustic Sensors, Selective Ion Sensors, Biosensors, ISFET based PH Sensor, Hybrid Microcircuits (HMCs) for SROSS and INSAT series of Satellites, Re-configurable System Design, Application Specific Instruction-set Processor Design, 16/32-bit Microprocessor Design, P-MOSFET Gamma-ray Dosimeter, Piezoresistive Pressure Sensor, Capacitive Pressure Sensor, InP-InGaAs based PIN Photo Detectors, 980nm Pump Laser Diode, C-band High-power GaAs MESFETs and Amplifiers

- 140 W Ku-band Space TWT, 2.6 MW Magnetron for LINAC, Mercury-free VUV/UV Plasma Source, Pseudospark Switches, Cathode System (MTRDC), Software Packages, Related Infrastructure & Technologies, High-power Microwave Window Technology, Long-life Dispenser Cathodes, 40 kV 3 kA Thyratron, 25 kV 1 kA Thyratron, Design and Technology Development for Gyrotron Devices, 6 MW Pulse 24 kW Average Power S-Band Klystron, 5 MW Pulsed S-band Klystron, 6 Ghz 20 W Helix TWT, 60 W Space TWT, S-band 30 W Helix TWT, Broadband 40 W Mini Helix TWT, C-band 75 kW CC-TWT, 3 MW Pulsed S-Band Magnetron, 2 MW S-band Tunable Pulsed Magnetron, S-band 1 MW Magnetron, S-band 500 kW Magnetron, S-band 400 W Carcinotron

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Cryptology: Securing Knowledge, Safeguarding Future

In a world increasingly connecting digitally, cryptology or the science of secure communication assumes great significance, with immense potential for research, employment and more

■ Dr Abhay Kumar Singh and Chiranjeev Bhaya

Cryptology is the science of secure communications. In this era where transfer of data is abundant, quick and available, there is a dire need of protection so that sensitive data is communicated in desired manner. Cryptology comprises two parts: cryptography and cryptanalysis. Cryptography serves

to maintain the secrecy of information and ensure the integrity of data by preventing unauthorized alterations. Cryptanalysis involves the identification of weaknesses in cryptography algorithms so as to improve them.

HISTORY OF CRYPTOLOGY

In historical contexts, classical cryptography denoted the practice of writing in a concealed manner, where 'crypto' signifies hidden or secret, and 'graphy' refers to writing in Greek.

The origins of cryptography can be traced back to the civilizations of ancient Rome and Egypt. Julius Caesar, the Roman emperor, employed an early and basic encryption method in which he transmitted confidential messages to his allies by shifting the letters in the plaintext message by a specific number of positions, referred to as the 'shift' or 'key'. This technique represents one of the earliest and simplest forms of encryption, known as a substitution cipher.

Across historical periods, cryptography has been a pivotal factor in wartime scenarios. Decrypting enemy messages holds the potential to yield crucial intelligence, contributing to the reduction of casualties and the achievement of victories. The cryptographers of the Al-

Image Courtesy: Wikimedia Commons

Reconstructed ancient Greek scytale, an early cipher device

lied forces played a significant role in shaping the outcome of World War II. Their proficiency in intercepting and deciphering messages encrypted on Japanese cipher machine Purple and German cipher machine Enigma bestowed a substantial advantage upon the Allies. This advantage proved instrumental in influencing the course of World War II, and without it, the conflict might have concluded differently.

During the early 1970s, IBM responded to the rising demand for encryption among their customers by establishing a 'crypto group', led by Horst Feistel. This group developed a cipher named Lucifer. In 1973, the National Bureau of Standards (now NIST) in the United States issued a request for proposals for a block cipher intended to become a national standard.

This move indicated their recognition of the deficiency in cryptographic support within the commercial products they were acquiring. Lucifer, designed by IBM's crypto group, was eventually accepted and became known as DES, standing for the Data Encryption Standard. However, in 1997 and subsequent years, DES faced a breach through an exhaustive search attack. The primary vulnerability of DES was attributed to the small size of the encryption key. As computational power increased, it became increasingly feasible to employ brute force methods to exhaustively test various key combinations and obtain potential plaintext messages.

In 1997, NIST once again sought proposals for a new block cipher and received 50 submissions. By the year 2000, NIST accepted Rijndael and officially named it AES, signifying the Advanced Encryption Standard. Presently, AES stands as a widely embraced standard for symmetric encryption.

The challenge with prevailing cryptographic algorithms lies in their reliance on one of three complex mathematical problems: the integer factorization problem, the discrete logarithm problem, and the elliptic-curve discrete logarithm problem. All these problems could be efficiently solved by a powerful quantum computer employing Shor's algorithm, or even faster and less resource-intensive alternatives, rendering the current encryption vulnerable. Post-quantum cryptography (PQC) represents the development of cryptographic algorithms, typically public-key algorithms, designed to withstand cryptanalytic attacks carried out by quantum computers.

Image Courtesy: Pixabay

Clockwise from top: Secure protocols such as HTTPS ensure confidentiality of online transactions; Advanced Encryption Standard or AES is widely embraced for symmetric encryption; Aadhaar relies on cryptology to ensure security and privacy of personal information

TERMINOLOGIES

Encryption and Decryption

Encryption involves transforming plaintext into ciphertext, making the original data unreadable to unauthorized individuals. This process employs cryptographic algorithms and keys to ensure confidentiality.

Decryption, the reverse of encryption, restores ciphertext to its original plaintext form. Both encryption and decryption play pivotal roles in maintaining the privacy and integrity of information.

Key

A key in cryptography is a piece of information used by an algorithm to perform encryption or decryption. Keys can be symmetric or asymmetric, with symmetric keys being shared between communicating parties, and asymmetric keys consisting of a public key for encryption and a private key for decryption.

Hash Function

A hash function converts input data into a fixed-length string of characters, known as a hash value or hash code. Commonly used for data integrity veri-

Image Courtesy: Wikimedia Commons

A 16th-century French cipher machine in the shape of a book, bearing the arms of Henry II of France (reign 1547-1559)

fication, hash functions are designed to be one-way, making it computationally infeasible to reverse the process.

Digital Signature

A digital signature is a cryptographic technique that authenticates the origin and integrity of digital messages or documents. It involves using a private key to generate a unique signature, which can be verified using the corresponding public key.

IMPORTANCE OF CRYPTOLOGY IN PRESENT TIMES

In the contemporary digital age, where information travels at the speed of light and communication transcends geographical boundaries, ensuring the security of sensitive data has become paramount.

Cryptology, therefore, plays a pivotal role in safeguarding information from unauthorized access and potential threats.

Rising Cybersecurity Threats

With the exponential growth of the internet and digital technologies, there is a corresponding increase in cybersecurity threats. Malicious actors, ranging from hackers and cybercriminals to state-sponsored entities, constantly seek to exploit vulnerabilities in communication networks. Cryptology provides a robust defence mechanism against such threats by employing cryptographic algorithms to encrypt and protect data during transmission.

Confidentiality and Privacy

Cryptology ensures the confidentiality and privacy of sensitive information. Through encryption techniques, data is transformed into an unreadable format that can only be deciphered by those with the appropriate cryptographic keys. This is particularly crucial in sectors such as finance, healthcare, and government, where the privacy of personal and confidential data is of utmost importance.

Integrity of Data

Maintaining the integrity of data is essential to ensure information remains unaltered during transmission. Cryptographic hash functions and digital signatures play a crucial role in verifying the authenticity and integrity of data. By generating unique digital fingerprints for files or messages, cryptology allows recipients to verify the origin and integrity of the information they receive.

Authentication and Access Control

Cryptology aids in robust user authentication and access control mechanisms. Multi-factor authentication, smart cards, and biometric authentication methods rely on cryptographic principles to ensure that only authorized individuals have access to sensitive systems or information. This helps prevent unauthorized access and protects against identity theft.

Global Communication and E-commerce

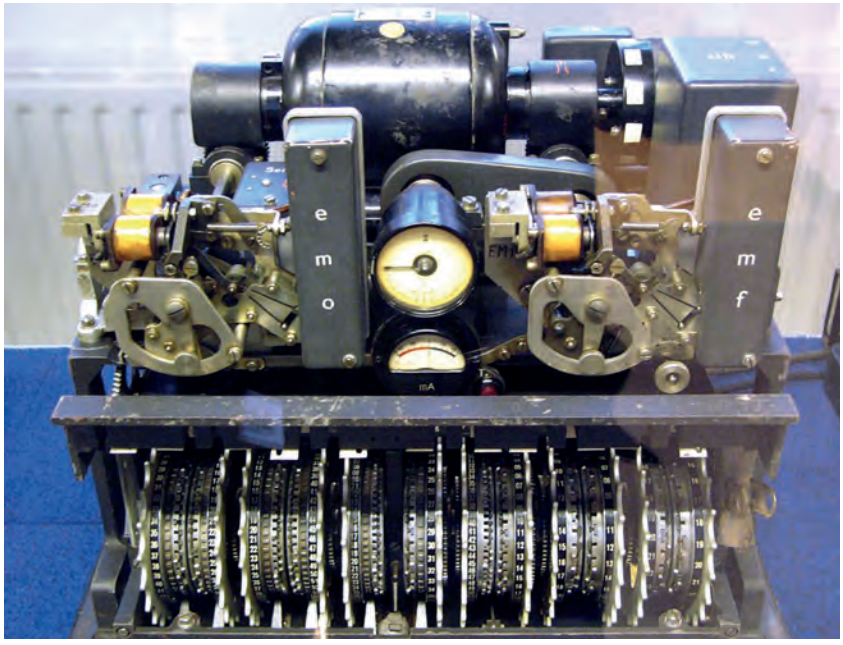
In the era of global connectivity and e-commerce, secure communication is the backbone of international trade and collaboration. Cryptology enables secure transactions and communications across borders, fostering trust in online interactions. It is the cornerstone of secure protocols such as HTTPS, ensuring the confidentiality of online transactions and the protection of sensitive financial information.

THE ROLE OF CRYPTOLOGY IN DIGITAL INDIA

In the wake of the digital revolution, India has embarked on a transformative journey towards becoming a digitally empowered society and a knowledge economy. The ambitious 'Digital India' initiative, launched by the Government of India, envisions a nation where technology is harnessed to empower citizens, enhance governance, and drive economic growth. Cryptology stands at the forefront of this digital transformation, ensuring the security and integrity of information in the vast landscape of the digital realm.

Secure Financial Transactions

Cryptology plays a crucial role in securing financial transactions, a cornerstone of the Digital India initiative. With the rise of online banking, digital wallets, and electronic payment systems, the need for secure and tamper-proof financial transactions is paramount. Cryptographic protocols such as Secure Sockets Layer (SSL) and Transport Layer Security (TLS) are instrumental in encrypt-



Left: Lorenz cipher machine, used in World War II to encrypt communications of the German High Command

Below: Horst Feistel led the 'crypto group' created by IBM in the 1970s in response to rising demand for encryption

Images Courtesy: Wikimedia Commons

ing data during online transactions, safeguarding the financial information of millions of users.

E-Governance and Data Security

As India moves towards a more transparent and efficient governance model through e-governance initiatives, the security of citizens' data becomes a top priority. Cryptology ensures the confidentiality and integrity of sensitive information stored and transmitted through government portals. Digital signatures and encryption technologies contribute to the creation of a secure and trustworthy digital ecosystem for government services.

Cybersecurity in Critical Infrastructure

The protection of critical infrastructure, including power grids, communication networks, and transportation systems, is vital for the nation's security. Cryptology is instrumental in implementing robust cybersecurity measures to safeguard these critical assets from cyber threats. Secure communication protocols and encryption techniques prevent unauthorized access and manipulation of critical infrastructure systems.

Digital signatures and encryption technologies contribute to the creation of a secure and trustworthy digital ecosystem for government services

Digital Identity and Aadhaar Security

The Aadhaar initiative, which provides a unique digital identity to Indian citizens, relies on cryptology to ensure the security and privacy of personal information. Cryptographic techniques, including biometric encryption and secure authentication protocols, help in protecting the Aadhaar database from unauthorized access and identity theft.

Healthcare and Telemedicine Security

In the era of digital healthcare and telemedicine, the protection of patient data and medical records is of paramount importance. Cryptology ensures the secure transmission of sensitive health information, maintaining patient confidentiality and protecting against data breaches. This is particularly crucial in the context of the ongoing digital transformation in the healthcare sector in India.

Promoting Trust in E-Commerce

E-commerce is a thriving sector in Digital India, and the trust of consumers is foundational to its success. Cryptology underpins secure online transactions, protects user data, and ensures the integrity of e-commerce platforms. The implementation of secure payment gateways and encrypted communication

Image Courtesy: eqmagpro.com

In an era characterised by evolving geopolitical challenges and technological advancements, the defence and national security of any nation, including India, depend heavily on the robustness of its communication systems and the protection of sensitive information

A variant of the Enigma machine, used by Germany's military and civil authorities from the late 1920s through World War II. It implemented a complex electro-mechanical polyalphabetic cipher

channels enhances consumer confidence in online transactions.

CRYPTOLOGY IN DEFENCE AND NATIONAL SECURITY OF INDIA

In an era characterised by evolving geopolitical challenges and technological advancements, the defence and national security of any nation, including India, depend heavily on the robustness of its communication systems and the protection of sensitive information. Cryptology plays a pivotal role in safeguarding national interests, ensuring the confidentiality of classified information, and fortifying communication channels against external threats.

Secure Communication Networks

Cryptology is fundamental in establishing secure communication networks for India's defence forces. Military operations require a high level of confidentiality, and cryptographic algorithms are employed to encrypt communication channels, making it extremely difficult for adversaries to intercept and decipher sensitive information. This ensures that strategic plans, tactical manoeuvres, and classified intelligence remain confidential.

Encryption of Classified Information

The protection of classified information is paramount in the defence and national security domain. Cryptology is instrumental in encrypting classified data, ensuring that even if it falls into the wrong hands, it remains indecipherable without the appropriate cryptographic keys. This is crucial for safeguarding military strategies, intelligence reports, and other sensitive information critical to national security.

Intelligence Gathering and Analysis

Cryptology supports the secure gathering and analysis of intelligence by protecting the communication channels used by intelligence agencies. The secure transmission of information between field operatives, analysts, and decision-makers is vital for effective counterterrorism efforts, border security, and overall strategic planning.

Secure Command and Control Systems

In the modern military landscape, command and control systems rely on secure communication to coordinate and execute operations. Cryptology ensures the integrity and authenticity of commands, preventing malicious actors from tampering with critical instructions or disrupting the military chain of command.

Cybersecurity and Resilience

As cyber threats become increasingly sophisticated, cryptology is indispensable in fortifying the cybersecurity posture of India's defence infrastructure. Advanced cryptographic techniques are employed to secure military networks, critical infrastructure, and sensitive databases, reducing the vulnerability to cyber-attacks that could compromise national security.

Diplomatic Communication Security

Cryptology also plays a role in securing diplomatic communication channels, ensuring the confidentiality of discussions between government officials and foreign counterparts. This is vital for fostering international relations, negotiating treaties, and addressing geopolitical challenges while protecting India's national interests.

Electronic Warfare Countermeasures

Cryptology contributes to developing countermeasures against electronic warfare tactics employed by adversaries. By implementing secure communication protocols and encryption, India can mitigate the impact of electronic warfare attacks, such as signal jamming or interception attempts, enhancing the resilience of its defence systems.

FUTURE OF CRYPTOLOGY

Cryptology has been a constant companion in the ever-changing landscape of information technology. As we stand on the precipice of an era defined by quantum computing, artificial intelligence, and the Internet of Things, the future of cryptology holds both challenges and unprecedented opportunities.

Quantum Cryptography

One of the most transformative advancements on the horizon is the advent of quantum computing. While traditional cryptographic algorithms rely on the difficulty of certain mathematical problems for security, quantum computers have the potential to break these algorithms with astonishing speed. Quantum cryptography emerges as a potential solution, leveraging the principles of quantum mechanics to create unbreakable cryptographic keys and secure communication channels.

Post-Quantum Cryptography

As quantum computing looms as a threat to traditional cryptography, researchers are actively working on developing post-quantum cryptographic algorithms. These algorithms aim to resist attacks from quantum computers and ensure the continued security of data in the quantum era. The transition to post-quantum cryptography is anticipated to be a critical element in maintaining the confidentiality and integrity of sensitive information.

Homomorphic Encryption

Homomorphic encryption, a cutting-edge cryptographic concept, allows computations to be performed on encrypted data without decrypting it. This has profound implications for privacy in data processing, enabling secure computation in cloud environments and facilitating confidential data analysis without compromising sensitive information. The future of cryptology may witness broader adoption of homomorphic encryption in various sectors.

Blockchain Technology

Cryptology and blockchain technology are intertwined, with cryptographic techniques ensuring the security and integrity of decentralized ledgers. As blockchain evolves, its applications in securing digital identities, financial transactions, and supply chain management will continue to grow. The future may see the integration of advanced cryptographic methods to further enhance the security and trustworthiness of blockchain networks.

Machine Learning and Adaptive Security

The integration of machine learning and artificial intelligence into the field of cryptology offers dynamic, adaptive security solutions. Systems that can learn and adapt to emerging threats in real-time, identifying patterns and anomalies, will be pivotal in staying ahead of rapidly evolving cyber threats. Cryptographic algorithms may become more adaptive and capable of evolving in response to new challenges.

As blockchain evolves, its applications in securing digital identities, financial transactions, and supply chain management will continue to grow

Multi-Party Computation

Multi-party computation (MPC) allows multiple parties to jointly compute a function over their inputs while keeping those inputs private. This emerging cryptographic technique holds promise for secure collaboration and data sharing among multiple entities without compromising individual data privacy. The future of cryptology may witness increased implementation of MPC in various sectors, including healthcare, finance, and research.

Global Collaboration and Standardization

In an interconnected world, the future of cryptology will likely involve increased global collaboration for standardization and the development of secure protocols. Standardizing cryptographic algorithms ensures interoperability, facilitates secure communication across borders, and promotes a unified approach to cybersecurity on a global scale.

As we peer into the future of cryptology, it is evident that the discipline will continue to evolve in response to emerging technologies and the dynamic threat landscape. From quantum-resistant algorithms to innovative encryption techniques, cryptology will play a pivotal role in ensuring the security and integrity of information in the digital age. The collaborative efforts of researchers, governments, and industry leaders will be essential in navigating the challenges and harnessing the vast potential that the future of cryptology holds. In this journey, the discipline will remain at the forefront of safeguarding sensitive information, privacy, and the foundations of secure communication.

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In Inspiring Memory of
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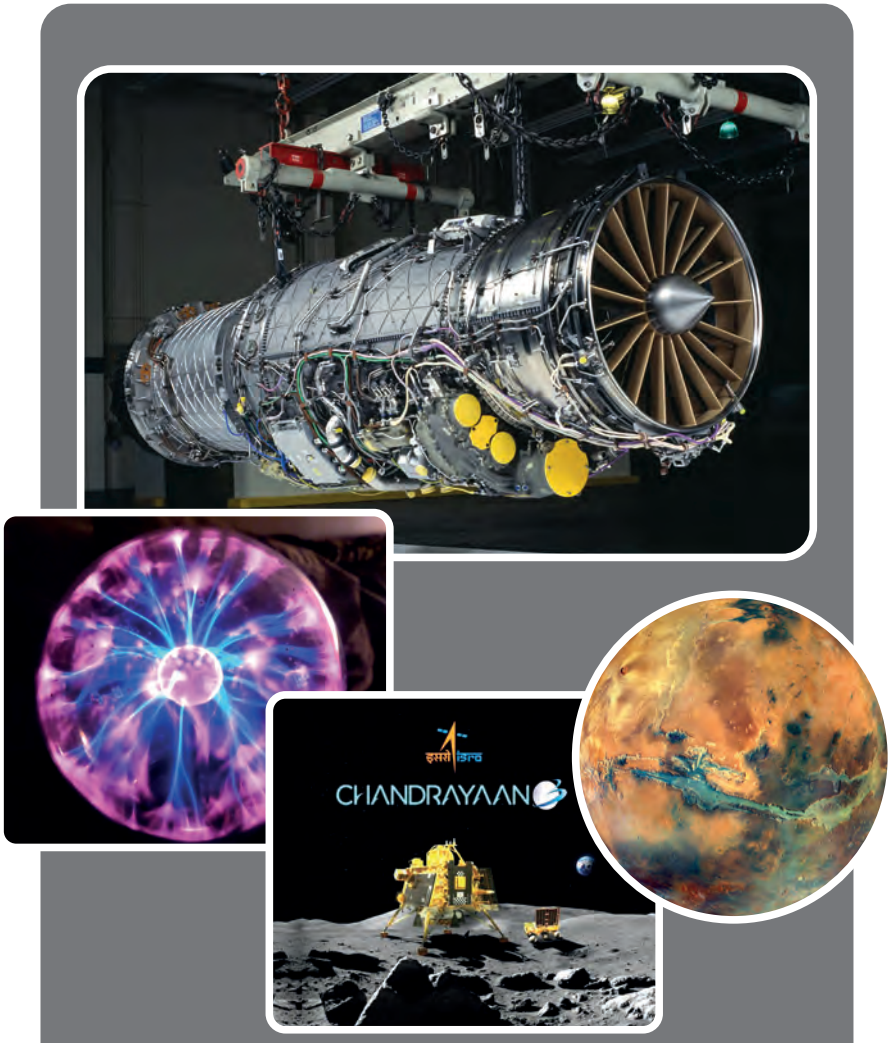


Major Science Landmarks of 2023

The year that is winding to a close will be remembered in India's history as a lodestar for the country's scientific achievements that rocked the world. Here's a look back

■ **Science India Bureau**

In 2023, India's scientific pursuits experienced exponential growth. The scientific community has pushed the limits of imagination and ingenuity with projects like the first solar mission launched by India and the signing of a jet engine deal with the US. Here are some of the biggest scientific landmarks of 2023.

SOLITARY WAVES ON MARS

Indian Institute of Geomagnetism (IIG), an autonomous institute of the Department of Science and Technology (DST), found evidence of 'solitary waves' in the weak magnetic field around Mars for the first time. Scientists used high-resolution electric field data from NASA's MAVEN spacecraft to make the discovery of solitary waves.

Despite several missions to Mars, the presence of 'solitary waves' in the Martian magnetosphere has never been reported earlier. The waves were found mostly in the morning and evening on Mars, at altitudes of 1000-3500 km, and their exact cause is still unknown.

NATIONAL QUANTUM MISSION

The Union Cabinet chaired by Prime Minister Narendra Modi approved the Naitonal Quantum Mission (NQM) on April 19 to aid scientific and industrial research and development in quantum technology.

National Quantum Mission will be implemented by the Department of Science & Technology (DST) under the Ministry of Science & Technology. The mission planned for 2023-2031 aims to seed, nurture and scale up scientific and industrial R&D and create a vibrant and innovative ecosystem in Quantum Technology (QT). India will join the US, Austria, Finland, France, Canada and China as the seventh nation to have a dedicated quantum mission with the launch of this mission. The goal of NQM is to develop 50-100 physical qubits in five years, and 50-1000 physical qubits in eight years, for intermediate scale quantum computers.

MANUFACTURING F414 ENGINE

On June 22, Indian announced a significant agreement between the American multinational corporation General Electric (GE) and Hindustan Aeronautics Limited (HAL), during PM Modi's state visit to the US. The deal involves the transfer of critical jet engine technologies and the manufacturing of GE's F414 engine for India's indigenous Light Combat Aircraft (LCA) Tejas Mk2. An important step forward has been made in India's quest for cutting-edge combat jet engine technology with this deal.

The US Navy has been using GE's F414 turbofan engine for more than 30 years. It has a six-stage high-pressure compressor, an advanced high-pressure turbine, a dual channel full authority digital engine control (FADEC), and a 'fueldraulic' system for nozzle area management.

PAPER-BASED SUPERCAPACITOR

Scientists at the Gujarat Energy Research and Management Institute (GERMI) achieved a breakthrough in energy storage technology with the development of a paper-based supercapacitor.

This innovative seaweed-based supercapacitor is lightweight, biodegradable and is able to fully charge a device in under 10 seconds. Researchers at GERMI have created the thinnest and lightest paper-based supercapacitor to date. The team has successfully developed an anodic paper supercapacitor that demonstrates outstanding tensile strength, performance and cost-effectiveness by utilizing cellulose nanofibers generated from seaweed.

CHANDRAYAAN-3'S VIKRAM LANDS ON MOON

In a lunar region never explored before, Chandrayaan-3 created history by being the first mission to make a soft landing on the lunar south pole on August 23, when its lander, Vikram, accomplished the feat. The mission's objectives were to show in-situ scientific investigations, safe and gentle lunar landing, and rover mobility.

India is now among the select four nations to have made a successful landing on moon, besides the US, China and Russia. The triumphant touchdown of Chandrayaan-3 followed the disappointment of the landing failure of Chandrayaan-2 mission in 2019. During descent, the Chandrayaan-2's Vikram lander had lost control and communication with the control station, resulting in a lunar crash. For Chandrayaan-3, the lessons from the previous mission were vital as the team created a 'failure-based' design method to pre-empt and address possible problems.

INDIGENOUS ASTRA BVR MISSILE

Tejas, Light Combat Aircraft (LCA) LSP-7, successfully fired the ASTRA indigenous Beyond Visual Range (BVR) air-to-air missile off the coast of Goa on August 23. The missile release was successfully carried out from the aircraft at an altitude of about 20,000 ft.

ASTRA, a state-of-the-art BVR air-to-air missile to engage and destroy highly manoeuvering supersonic aerial targets, is designed and developed by Defence Research and Development Laboratory (DRDL), Research Centre Imarat (RCI) and other laboratories of DRDO. The indigenous Astra BVR firing from home grown Tejas fighter is a major step towards 'Aatmanirbhar Bharat'.

The test launch was monitored by the Test Director and scientists of Aeronautical Development Agency (ADA), Defence Research and Development Organisation (DRDO), Hindustan Aeronautics Limited (HAL) along with officials from Centre for Military Airworthiness and Certification (CEMILAC) and Directorate General of Aeronautical Quality Assurance (DGAQA). The aircraft was also monitored by a Chase Tejas twin seater aircraft.

MAIDEN SOLAR MISSION ADITYA-L1

Aditya-L1, the Indian Space Research Organisation's first solar mission, was successfully launched on September 2. The PSLV-C57 rocket was used for the launch. For the first time in ISRO's history, the fourth stage of the PSLV was fired twice to perfectly place the satellite into its elliptical orbit.

The first space-based observatory class Indian solar mission, Aditya-L1, is capable of studying the Sun from a significant 1.5 million-kilometer distance. Approximately 125 days will pass before reaching the L1 milestone. After AstroSat (2015), Aditya-L1 is also ISRO's second astronomy observatory-class mission. The mission's trajectory is noticeably shorter than that of Mangalyaan, India's Mars Orbiter Mission (2013). The intended location for the spacecraft is a halo orbit around the Sun-Earth system's Lagrange point 1 (L1).

The mission seeks to offer important new understandings of the solar wind, photosphere, chromosphere and corona. Understanding the Sun's behaviour — including its radiation, heat, particle flow and magnetic fields — and how it affects the Earth is the main goal of Aditya-L1.

BIOFUEL ALLIANCE

India announced the formation of the worldwide Biofuel Alliance on September 9 and appealed to the G-20 countries to support the effort in order to raise the worldwide standard for ethanol blends with petrol to 20%.

On the fringes of the G-20 Summit, PM Modi announced the formation of the alliance with a number of world leaders, such as Italian Prime Minister Giorgia Meloni, Brazilian President Luiz Inacio Lula da Silva, US President Joe Bide and Prime of Bangladesh Sheikh Hasina.

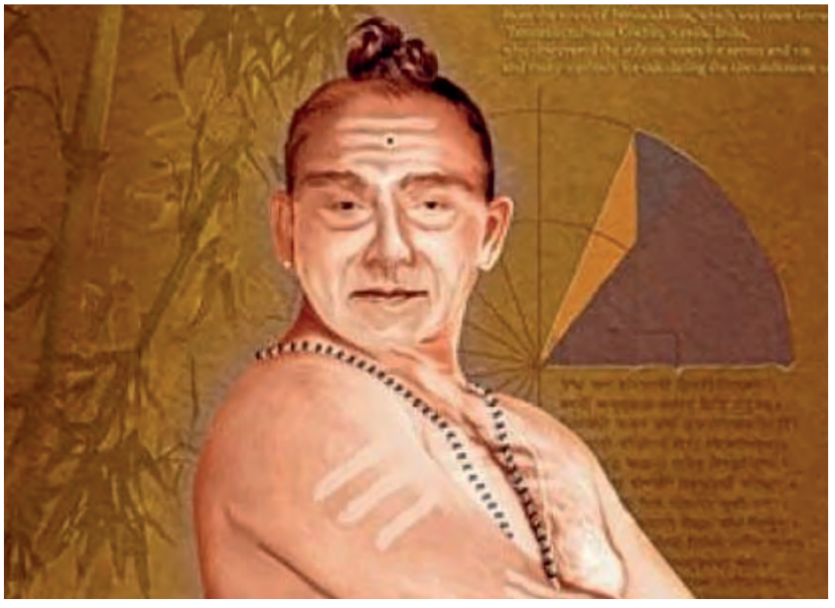
A biofuel is any hydrocarbon fuel that is created quickly — in a matter of days, weeks, or even months — from organic matter, which is living or once-living material. They can be used to produce electricity, heat homes and power cars. Because they are derived from plants that can be cultivated repeatedly, biofuels are regarded as renewable resources. Biofuels come in liquid, solid and gaseous forms. Biofuels can be used in place of or in addition to fossil fuels for a variety of purposes, including the production of power and heat.

NATIONAL MATHEMATICS DAY / DECEMBER 22

The Legacy of Sangamagrama Madhava and Kerala School of Astronomy and Mathematics

With pathbreaking contributions to infinite series and calculus, among other mathematical concepts, the Kerala School (14th-18th centuries) represented a high point of Indian mathematics which needs wider currency in the world today

■ Prof VPN Nampoori



All Images Courtesy: Prof VPN Nampoori

Mathematician and astronomer Sangamagrama Madhava (c. 1340- c. 1425) is considered the founder of Kerala school of astronomy and mathematics

Mind is the true laboratory where behind illusions we uncover the laws of truth. It is in this context that we introduce one of the greatest Indian mathematicians who lived in Kerala during the middle ages. Astronomical and mathematical development in India is not well known after 10th century AD and many important works that prove the presence of many great astronomers and mathematicians of Kerala remain little known in the field of history of science. One such great astronomer-mathematician was Madhava of Sangamagrama. Sangamagrama Madhava's work *Venuaroham* was used for the computation of the true longitude of the moon. Sangamagrama Madhava was one of the great geniuses of the time before Keplar and Newton. He lived in Irinjalakkuda in the 14th century AD. Among his works, only *Venuaroham* and *Sphutachandrapti* are available in print and the rest are known through references made by his *shishyas*. In the following sections, we introduce some of the works of Sangamagrama Madhava and members of the Kerala School.

While Europe was divided in modeling solar system to geocentric and heliocentric systems even in the 17th century, an astronomer-mathematician from Kerala during the 16th century described observational studies as geocentric which can be transformed into a mathematical model with the sun as the centre. Neelakanda Somayaji, a 16th century astronomer-mathematician belonging to a long *guru-sishya parampara* chain of five hundred years of length, describes in his work, *Tantra Sangraha*, the subject of observational astronomy along with necessary mathematical techniques.

It is without doubt that mathematics today owes a huge debt to the outstanding contributions made by Indian astronomers and mathematicians over many hundreds of years divided into

Image Courtesy: Wikimedia Commons

The Irinjatappally Mana, which is believed to be the birth place of Sangamagrama Madhava

ancient, classical, medieval and modern periods. Chief among astronomers-mathematicians from each period are: Ancient: Apastamba, Baudhayana, Katyayana, Manava, Panini, Pingala and Yajnavalkya; Classical: Vararuchi, Aryabhata, Varahamihira, Brahmagupta; Medieval: Narayana Pandita, Bhaskaracharya, Sangamagrama Madhava, Nilakanda Somayaji, Jyestadeva, Achuta Pisharoti, Melpathur Narayan Bhattathiri, Sankaravarman; and Modern: Srinivas Ramanujan, Harish Chandra, Narendra Karmakar, S Chandrasekhar, SN Bose.

The beautiful number system (zero and decimal system) invented by the Indians on which mathematical development has rested is complimented by Laplace as: 'The ingenious method of expressing every possible number using a set of ten symbols (each symbol having a place value and an absolute value) emerged in India. The idea seems so simple nowadays that its significance and profound importance is no longer appreciated. Its simplicity lies in the way it facilitated calculation and placed arithmetic foremost amongst useful inventions. The importance of this invention is more readily appreciated when one considers that it was beyond the two greatest men of antiquity, Archimedes and Apollonius. It was Einstein who said we should be grateful to Indians who taught us how to count.'

French polymath Pierre Simon Marquis de Laplace said: 'The ingenious method of expressing every possible number using a set of ten symbols (each symbol having a place value and an absolute value) emerged in India... It was Einstein who said we should be grateful to Indians who taught us how to count'

While the rest of the world was in the dark ages, India made strides in Mathematics. The legacy of the last 3000 years runs to this day, through the works of Sulbakaras (800-600 BC), Aryabhata, Varahamihira, Brahmagupta, Bhaskaracharya, Sangamagrama Madhava, Nilakanda Somayaji, Jyeshtadeva, Sankaravarman extending to those of Srinivasa Ramanujan, SN Bose, Harish Chandra, Prasanta Chandra Mahalanobis, and reaching to the current period of Narendra Karmakar, Jayant Narlikar, SR Srinivasa Varadhan, ECG Sudarsan and Thanu Padmanabhan.

Political chaos caused halting of fur-

ther generation of new knowledge in North India while Kerala, at the south-western tip of India, escaped the majority of such political upheaval, allowing a generally peaceful atmosphere for the 'uninterrupted' pursuit of scientific development. It is hailed as the second Golden Age of Indian Mathematics, first being the period of 5th century AD to 10th Century AD.

It has come to light only during the last few decades of the 20th century that mathematics (and astronomy) continued to flourish in Kerala for several hundred years during the medieval era, especially from the 14th-18th century. Kerala mathematics was strongly influenced by astronomy leading to the derivation of mathematical results of very high importance. As a result of the untiring works of people like Prof KV Sharma, who found that only about 1% of the total available manuscripts in mathematics and astronomy in Kerala is deciphered and made known to the world while the rest is still under the vast unexplored ocean of knowledge. It is quite probable that there are still further discoveries of 'Kerala mathematics' to be made, and a full analysis has yet to be carried out even though several findings have already been showed that several major concepts of renaissance European mathematics attributed to stalwarts like Newton, Leibnitz, Gregory, Taylor and Euler were first developed in India. This further demands the necessity of mining out the unexplored landscapes of Kerala mathematics so that we may be lucky enough to get gems of high values and qualities. In this context we should remember a self-taught mathematician from Trivandrum, P Padmakumar, who discovered astonishing properties of the magic square called Srirama Chakram in respect of number theory and astronomy, which is now known as Magic Square. We should promote the works of such people among us who are capable of carrying out such wonderful jobs of deciphering our ancient knowledge.


സംഗമഗ്രാമ മാധവന്റെ വാനനിരീക്ഷണകേന്ദ്രം പുനർനിർമിച്ചില്ല

ചരിത്രശേഷിപ്പ് വിസ്മൃതിയിലാകുമോ...

A newspaper report on how Madhava temple has been destroyed

Political chaos caused halting of further generation of new knowledge in North India while Kerala, at the south-western tip of India, escaped the majority of such political upheaval, allowing a generally peaceful atmosphere for the 'uninterrupted' pursuit of scientific development. It is hailed as the second Golden Age of Indian Mathematics

SANGAMAGRAMA MADHAVA

Of all the mathematicians of medieval period, name of Sangamagrama Madhava is the most important who founded a continuous chain of Guru Shishya *parampara* from the 14th century to the 18th century, and is generally known as Kerala School of Mathematics. Sangamagrama Madhava and his school were known to the western world through a series of papers published by Charles Whish in 1834 in the journal called *Transactions of Asiatic Society of Great Britain and Ireland*. In his series of papers, Whish showed that works of Newton, Leibnitz, Gregory and others (who lived during 17th -18th century) were just rediscoveries of the mathematics contributed by Kerala School. However, his works did not get much attention from the academicians and researchers of the west. Only after one century of Whish's works that the world started knowing and admiring the valuable contributions of Kerala Mathematics thorough Prof SK Sharma, C Rajagopal and his colleagues.

SANGAMAGRAMA MADHAVA'S ORIGINS

From a quartet from one of the works of Madhava (which is the only available work of Madhava), namely Venuaroham, his place of birth is in Kallettinkara village in Irinjalakkuda, which is about 2 km from Irinjalakkuda Railway station. From the following sloka (quartet) from Venuaroham, it is clear that the mathematician-astronomer was born to the family known as Irinjarappally and his given name was Madhava.

Image Courtesy: Wikimedia Commons

Branches of a bamboo stem (Venu) go up alternately left and right and hence the method of Sangamagrama Madhava to evaluate the position of Moon in the sky is known as Venuaroham

Bakuladhishtithathwena / Viharo yo visishyathe
Gruhanamani soyam syath / Nijanamani Madhava (Venuaroham, 13th sloka)

(I, bearing the name Madhav, was born to the family bearing the house name (*vihara* with a Bakula tree nearby) Irinjarappally. (There is a family residing in Kallettinkara with the name Irinjarappally.)

The family temple of Madhava with Sree Krishna as the deity is near the Irinjarappally house. We can see two granite blocks in the campus of the temple which were used by Madhava, one for meditation and the other to observe the night sky by lying down on the granite bed.

It is a matter of concern that the present generation in Irinjalakkuda is not aware of this great mathematician-astronomer who worked under the same sky and walked the same piece of earth. With the help of Cochin University of Science and Technology, we have conducted a series of workshops and seminars in Irinjalakkuda where experts in the field of Mathematics, Physics and Astronomy took classes which benefited nearby school and college students. With the help of a local college, a documentary on Sangamagrama Madhava was produced for the benefit of the public.

One of the members of the Kerala School, namely Jyeshtadeva needs special mention. While the rest of the scholars wrote their works in Sanskrit, Jyeshtadeva wrote his book, *Yukthi Bhasha*, a treatise in mathematics and astronomy, in Malayalam for wider dissemination of knowledge

A member of the Kerala School, Jyeshtadeva, needs special mention. While the rest of the scholars wrote their works in Sanskrit, Jyeshtadeva wrote his book, *Yukthi Bhasha*, a treatise in mathematics and astronomy, in Malayalam for wider dissemination of the knowledge. Attempts are being made by experts to decipher the book *Yukthi Bhasha* in the light of modern mathematics. The mathematical and astronomical studies carried out by Kerala School must be studied and explored.

SOME OF THE MAIN CONTRIBUTIONS OF SANGAMAGRAMA MADHAVA

We know that one of the major contributions of Indian Mathematics is the concept of Zero and the decimal number system. One cannot pinpoint the discovery of Zero to any particular person. Another important contribution to the world of mathematics is the concept of infinity imported to mathematics, the credit of which goes to Sangamagrama Madhava. He was able to show that one can get a finite value by adding infinite terms or a finite value can be expressed as an infinite series. Usually, this discovery is attributed to Gregory, Newton, Taylor and others. Historians of mathematics have started acknowledging this fact and have started renaming some of the well-known series as Madhava-Gregory Series, Madhava-Newton Series, Madhava-Taylor Series, etc.

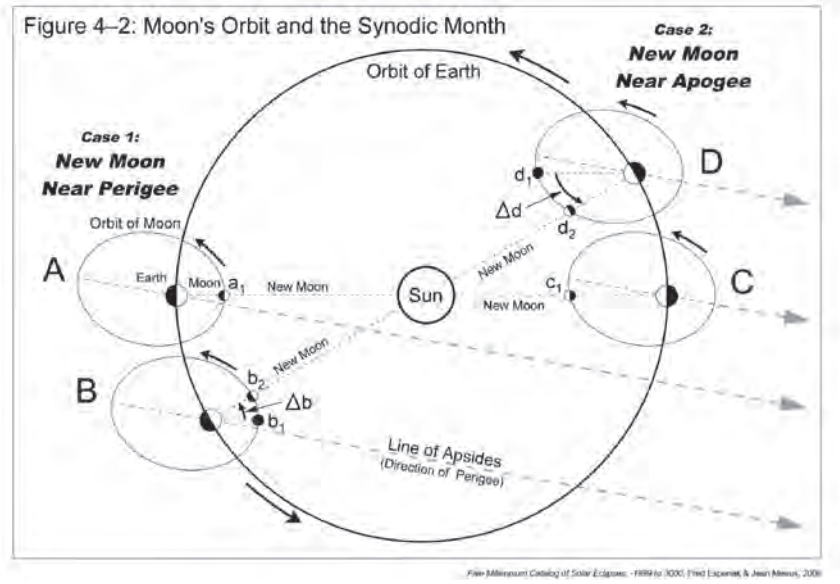
It is quite interesting to note that both the concepts of zero and infinity are contributions of India which influenced the Indian systems of Philosophy to a great extent. The concept of infinity could have been there in the mind of Indian Philosophers. That is why, we have a *sloka* in *Isavasyopanisha* which means:

That is infinite, this is infinite, when infinity is added to infinity, infinity remains and when infinity is taken from infinity, infinity remains.

This is true for zero also. No wonder that Indians represent the infinite extension of the sky with number zero in Bootasankhya representation of numbers.

Madhava tamed the infinity to generate finite values by adding infinite terms. Some of the infinite series discovered by Madhava were rediscovered by European mathematicians about two to three centuries later as detailed by the Cambridge University Professor of Mathematics George Gheverghese Joseph. Some of such infinite series discovered by Madhava are Madhava- Gregory series, Madhava-Newton series, Madhava-Leibnitz series, Madhava -Gregory-Leibnitz series, and Madhava-Taylor series.

The discovery of infinite series in trigonometry for sine and cosine alone is sufficient to consider Sangamagrama Madhava as equal to Newton, Leibnitz, Lagrange, Laplace, etc. Another important contribution by Madhava is the representation of the irrational number 'pi' as an infinite series.



An image depicting Moon's orbit and the synodic month

We know that one of the major contributions of Indian Mathematics is the concept of Zero and the decimal number system. Another important contribution is the concept of infinity imported to mathematics, the credit of which goes to Sangamagrama Madhava

Madhava used the infinite series formula to evaluate the value of pi correctly to 11 decimal places as 3.14159265359. Recent studies show that calculus, an important branch of Modern Mathematics, originated in Kerala School well before the time of Newton and Leibnitz. In Jyestadeva's *Yukthi Bhasha*, which dates hundred years before the time of Newton and Leibnitz, we find the formulae for integration and differentiation. It is said that *Yukthi Bhasha* is the first text book in the world dealing with Calculus .

TABLE OF TRIGONOMETRIC TERM SINE OF ANGLE

Another wonderful contribution of Sangamagrama Madhava is his table for Sine of an angle from zero to 90 degrees at an interval of 3.75 degrees. The values are represented in word numerals called *katapayadi* number system invented by Vararuchi during the 5th century AD. The table is represented as *sloka* as given below:

For example sin (7.5) has the value हिमाद्रिर्वेदभावनः (himadrirvedabhavanah =0.13052623 and modern value for sin 7.5 is 0.13052619!

Venuaroham

Venuaroham is one of the most important works of Madhava which describes the true positions (longitudes) of the moon in the sky. Information about the moon's correct position is needed since time for *yajna*s, *pooja*s, etc. are calculated based on this knowledge. Calculations are based on the anomalistic cycle of the moon around the earth.

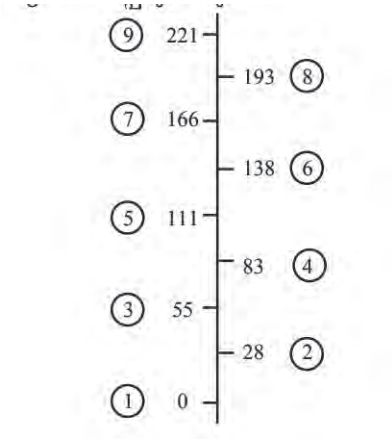
ANOMALISTIC CYCLE USED BY SANGAMAGRAMA MADHAVA

The fundamental lunar cycles in relation to the Earth are the Synodic cycle, which has a period of 29.5 days (New Moon to New Moon) and the Anomalistic cycle (perigee to perigee) which is 27 days 13hrs 18min 34.45s (about 27.5 days). Anomalistic cycles from a zero epoch will end respectively at cycle no., days, h, m, s as follows (for example the first cycle 1 ends at 27d , 13 h, 18min, 34.45 sec) :

1, 27,13 18 34.45
2, 55, 02,37, 08.90
3, 82, 15, 55, 43.35
4, 110, 05, 14, 17.79
5, 137, 18, 32, 52.24
6, 165, 07, 51, 36.69
7, 192, 21, 10, 01.14
8, 220, 10, 38, 35.59
9, 247, 23, 47, 10.04

Note that the difference between successive cycles is about 12 hours and alternate cycles is about 24 hours . This means that the successive durations are alternately corresponding to day-night, day-night difference.

Nine cycles constitute nearly 248 days and the difference in longitudes of successive days (delta lambda) constitute the *chandravakya*s developed by Madhava based on the *katapayadi* number system. The series of *vakya*s begins from the moment when the moon is at apogee (*Chandra thunga yogam*) and each *vakya* corresponds to successive day's longitude of the moon.



Dhruvas (circled, descending order) and Vakya number (ascending order). The difference between sucessive Vakya number is 28 and are alternate at left (night) and right (day)

ALGORITHM OF MADHAVA

Position of the moon and the apogee coincide during a time called Dhruvam or *dhruva kalam*. The algorithm of Madhava is based on Computation of 9 *dhruvas* (D1, … D9) using Madhava's constant and Kalidina K. When position of the moon and the apogee coincide during a time, Dhruvam or *dhruva kalam*, from that point of time there will be 9 *Chandra thunga yogam* which can be computed as follows. For each moon revolution around the earth, the *Chandra thunga yogam* will get shifted by 3 degrees every day. To start with a reference point, the starting point will be when *Chandra thunga yogam* happens at sunrise (Suryodaya Madhya). How many days have completed when the *Chandra thunga yogam* takes place at Suryodaya Madhya. The number of days of this type is 188611 and the completed moon's orbiting around the earth is 6845. From this we can calculate the moon orbiting period as 188611/ 6845 = 27.5 days approximately (27 days 13h 18m 34.45s to be exact). Based on Madhava's algorithm, we can find that anomalistic cycles from a zero epoch will end respectively at Dhruvas B1 to B9 at 6460, 3411, 362, 4158, 1109, 4905, 1856, 5652, and 2603 respectively and corresponding *chandravakya* S1 to S9 as 0, 28, 56, 83, 111, 138, 166, 193, and 221 respectively.

We can represent *chandravakyas* with corresponding Dhruvas as shown in the figure. Vakyas are arranged in ascending order while corresponding *dhruvas* are in descending order. The successive difference between *chandravakyas* is 28 appearing on the day side on the right and night side on the left. This is like branches of a bamboo stem (Venu) going up alternately left and right in a bamboo pole or venu pole and hence the method of Sangamagrama Madhava to evaluate position of Moon in the sky is known as VENUAROHAM.

CONCLUSION

In the above sections, we presented a bird's eye view of the wonderful works carried out by Sangamagrama Madhava and his school. In order to expand the present work being carried out, it is proposed to submit a project to the Ministry of Tourism for financial help so as to set up a memorial consisting of a research centre with infrastructure facilities for a library, museum and lecture theatre.

At Kallettinkara of Irinjalakkuda, students will be introduced to Indian School of Mathematics in general with stress on the Kerala School along with introductory Sanskrit classes. In future, it is proposed to transform Irinjalakkuda to an academic, spiritual and intellectual tourist destination with varied related activities.

During a recent storm in the neighborhood of the temple and rain, the temple was damaged when a tree fell over it. The trustees of the temple do not have sufficient budget to repair the damage. It will be a good gesture if readers of this article and their friends can help the trustees financially so that the temple can be restored and renovated to its original structure.

**The writer is visiting professor at the International School of Photonics, Cochin University of Science and Technology, Kochi; Kerala University, Thiruvananthapuram, and MG University, Kottayam. He can be reached at nampoori@gmail.com.*

INTELLECTUAL PROPERTY RIGHTS

A Vital Pillar for National Progress

The issue of intellectual property is especially important in a country like India with an endless heritage of traditional scientific knowledge that can easily be misappropriated

Images Courtesy: Flicker

Innovation is a catalyst for progress in a country, driving economic growth, enhancing competitiveness, and improving the overall well-being of its citizens. Nations that prioritise and allocate resources towards innovation are in a more advantageous position to overcome difficulties of the contemporary world and ensure a stable and thriving future.

Innovation also brings competitiveness. If one doesn't protect their innovation, the chance of it being exploited by others is higher. Protecting the innovators' intellectual property is the highest priority in today's world. Intellectual property rights arise in the contemporary context when intellectual creations

■ **Dr Biju Dharmapalan**

Turmeric and Indian Basmati have been at the centre of biopiracy controversy when US patents were granted on these products, in flagrant disregard of primacy of India's traditional and historical claim over the two. Those patents were later revoked after India put up a fight

are generally accessible, and an endeavour is made to profit from someone else's work.

A patent is a type of intellectual property right that the government grants as an official legal claim. This agreement gives an inventor the only rights to manufacture, sell, and use their invention for a specified period of time. A patent is a legal authorisation granted by the government to an inventor, giving them the exclusive right to prevent others from producing, using, or selling their creation, typically for a specific duration. Patents are awarded for novel and practical machinery, manufactured goods, industrial procedures, and notable enhancements to existing ones. Patents are also awarded for novel chemical compounds, edibles, and therapeutic substances, in addition to the methods employed in their production. Patents can be granted in certain countries for novel variations of plant or animal life that have been created using genetic engineering techniques. Apart from this, there are many other means, like copyrights, trademarks, design etc., to protect intellectual property. Patents play a crucial role in fostering innovation, economic development, and intellectual property protection.

Image Courtesy: Researchgate.net

India is the first country to share benefits of traditional knowledge with the people who possess it, as in the case of the Kani tribe whose knowledge of anti-fatigue property of a herb, Trichopus zeylanicus (seen in the hands of a member of the tribe here) has been used to prepare a herbal formulation. 50% of license fee for this formulation has been shared by the government with the tribe

DIFFERENT TYPES OF INTELLECTUAL PROPERTY RIGHTS

Copyright
Copyright protects original works of authorship, such as literary works, music, art, and software. It gives the creator exclusive rights to reproduce, distribute, perform, and display their work.

Trademark
Trademarks protect symbols, names, logos, and other distinctive elements that identify and distinguish goods or services. Trademarks help consumers identify the source of a product or service.

Patent
Patents protect inventions, providing inventors with exclusive rights to their creations for a limited period. This exclusivity allows inventors to control the use, manufacture, and sale of their inventions.

Industrial Design
Industrial design rights protect the visual design of objects, such as the shape, surface, or ornamentation. This category is particularly relevant to product designers and manufacturers.

Trade Secret
Trade secrets are confidential business information, such as manufacturing processes, formulas, designs, or customer lists, that provide a competitive advantage. Unlike patents, trade secrets are protected without registration as long as they remain confidential.

Integrated Circuit Layout Design Protection
Protects the layout designs of integrated circuits, preventing unauthorised copying or use.

Database Rights
Protects the investment made in compiling databases, granting certain rights to the creators or owners of the databases.

Geographical Indication (GI)
A Geographical Indication is a sign used on products that have a specific geographical origin and possess qualities, reputation, or characteristics that are essentially attributable to that place of origin.

Plant Variety Protection
Protects new varieties of plants, providing exclusive rights to the breeder to control the use of the new variety.

Traditional Knowledge Protection
Aims to protect the traditional knowledge and practices of indigenous communities from unauthorised use or exploitation.

According to the recent World Intellectual Property Indicators Report, patent applications by residents of India grew by 31.6% in 2022, extending an 11-year run of growth unmatched by any other country among the top 10 filers. Prime Minister Narendra Modi has welcomed the rise in patent applications in India. In a post on the X (formerly Twitter) platform, the Prime Minister commented, “The rise in patent applications in India demonstrate the rising innovative zeal of our youth and is a very positive sign for the times to come”.

RISE IN PATENT APPLICATIONS FROM INDIA
According to a report prepared by Nasscom, out of the 5,84,000 patents filed in India between FY2010 and FY2022, some 2,66,000 were from the technology domain, and 1,60,000 of these technology patents were from emerging technologies like AI, IoT, Big Data,

Cybersecurity, and Blockchain. Of the total patents filed in the telecommunications sector, around 2.4% were related to emerging areas such as 5G and 6G. In a comment published in *The Hindu*, Debjani Ghosh, president Nasscom mentioned, "India's adoption of emerging technologies has led to a surge in innovation, as evidenced by the increasing number of patent filings. This trend highlights India's position on the global innovation map and its leadership in emerging technologies such as AI".

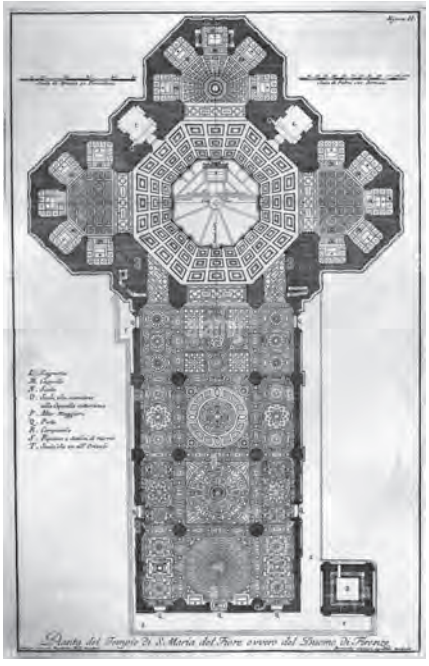
LAUNCH OF 'MAKE IN INDIA' INITIATIVE IN 2014

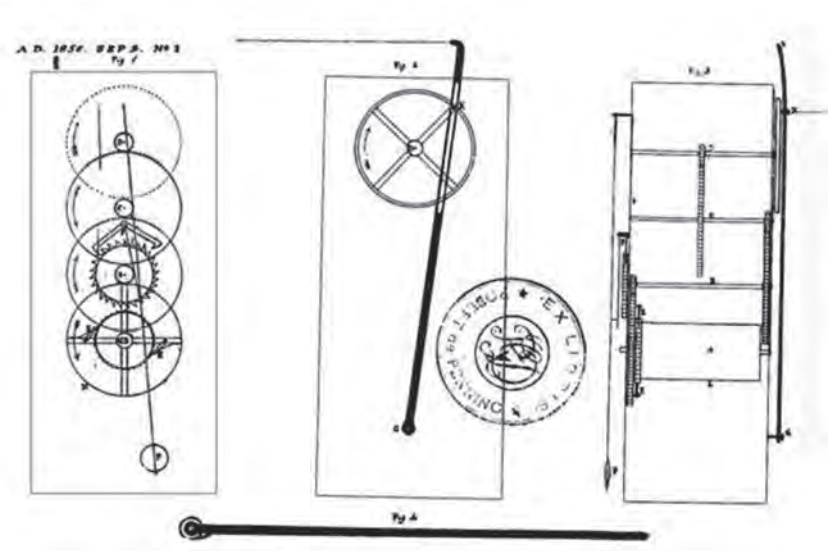
This rise is due to various initiatives that Prime Minister Modi implemented, such as the 'Make in India' campaign. The 'Make in India' programme was initiated on September 25, 2014, to promote investment, encourage creativity, develop top-notch infrastructure, and establish India as a manufacturing, design, and innovation centre. Establishing a resilient manufacturing industry remains a crucial objective for the Indian government. The 'Make in India' project has achieved notable milestones since its inception. As of March 2021, 5544 patent applications have been filed from the start-ups started under the 'Make in India' initiative, and 577 patents were granted. The development and commercialisation of new products and technologies can lead to job creation, increased productivity, and the growth of industries.

HISTORICAL PERSPECTIVES

There was no formal system for protecting intellectual property rights in ancient cultures as we understand them today. Especially in our great Indian culture, knowledge was intended to be freely accessed by all. Knowledge and skills were transmitted orally or through apprenticeships in many ancient cultures. Artisans, including architects, often passed down their techniques and designs within a family or a close-knit community. The oral tradition allowed them to control their knowledge while minimising the risk of unauthorised replication. People never took advantage of another's work. The magnificent, unique architecture of our ancient temples is a perfect example of this. Ramappa Temple in Telangana was constructed in the year 1213 CE by Recharla Rudra, a general of Kakatiya ruler Ganapati Deva. It is the only temple in India that is named after the architect, showing the magnanimity of the rulers of the time. Recently, UNESCO granted this temple a World Heritage Site tag because of its unique earthquake-resistant architecture. For Indians, the concept of patent was an alien culture received from foreigners. Even the great Indian polymath Sir Jagadish Chandra Bose was averse to the western idea of patents. Bose was against patenting because he believed knowledge should be available to everyone and not be constrained by patenting. For him, "It is not the inventor but the invention that matters." Because of this, the actual 'Father of Radio Science' was forgotten by the scientific community.

The first recorded industrial patent was granted in 1421 to Filippo Brunelleschi, a Florentine engineer and architect who invented a new way to transport marble from quarries on the river Arno via barge. The patent gave him exclusive rights to produce barges equipped with hoisting gear for the transportation of marble for three years. 'Il Badalona' was the name of the ship that Brunelleschi patented. While the patent text does not include the ship's technical description, various drawings



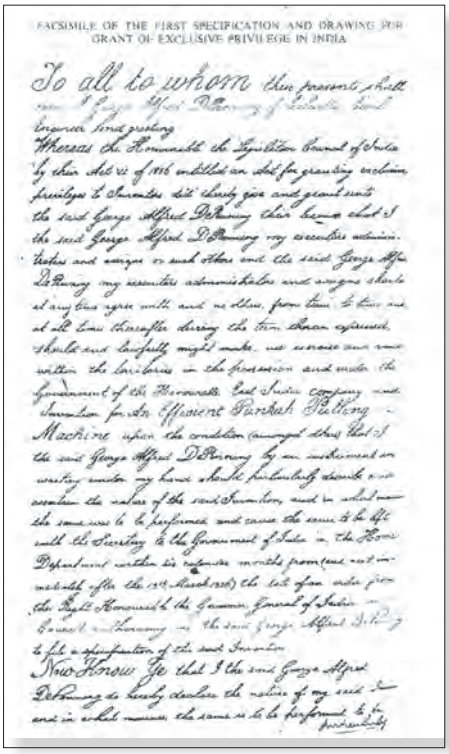


Left: Patent sketches submitted by Filippo Brunelleschi, who is the first individual historically to be granted a patent, in 1421. Above: Patent sketches made by George Alfred DePenning, the first applicant for a patent in India

provide enough information to understand the ship's appearance. Although the Notice by the Lords of Florence is not a 'patent' with the structure we know today (description, claims, etc.), it contains all the basic principles on which the patent system is based.

The first official patent system emerged in Renaissance Italy in 1474 with the publication of the Venetian Patent Statute in Venice. The Venetian Patent Law, established to foster technological advancement and safeguard the interests of indigenous craftsmen, holds the distinction of being the oldest legislative patent system in Europe and globally. Between 1474 and 1788, the Venetian Senate issued around 2,000 patents. The Industrial Revolution in the 18th and 19th centuries led to an increase in inventions and innovations. Countries began establishing formal patent offices to manage the growing number of patent applications.

The origins of patents in India can be traced back to the colonial period. The initial legislation in India concerning patents was the Act VI of 1856, which has undergone gradual transformations. When the British colonisation of India ended, the Indian Patents and Designs Act, 1911, was in force and had created a system of patent administration in India under an administrative office — the Controller of Patents and Designs. The first Indian patent was awarded to George Alfred DePenning, a civil engineer residing at 7, Grant's Lane, Calcutta. DePenning submitted a petition to the Government of India on March 3, 1856, requesting exclusive privileges for his invention, 'An Efficient Punkah Pulling Machine'. On September 2, DePenning submitted the specifications and functional drawings for his invention, which served to illustrate its operation. The invention was awarded the inaugural Intellectual Property protection in India subsequent to its acceptance. After establishing his legacy in Indian history, George Alfred DePenning observed other inventors grappling with the complexities of patent protection and perceived an opportunity to assist them as patent agent. In


FACSIMILE OF THE FIRST SPECIFICATION AND DRAWING FOR GRANT OF EXCLUSIVE PRIVILEGE IN INDIA

To all to whom these presents shall come

An order granting patent to George Alfred DePenning for a 'punkah pulling machine' in 1856. This was the first ever patent to be granted in India

India, DePenning was appointed as the first Patent Agent.

Following India's independence, the country established its initial independent patent law in 1970. This development was influenced by the findings of two committees tasked with providing recommendations: the Bakshi Tekchand Committee in 1949 and, subsequently, the Justice Rajagopal Ayyangar Committee. These recommendations played a pivotal role in instigating substantial changes to Indian patent law, ultimately culminating in the enactment of the Patents Act of 1970. This legislation replaced the existing Indian Patents and Designs Act of 1911. The Patents Bill was initially introduced in 1965 and underwent amendments in 1967. The Patents Act of 1970 and the accompanying Patents Rules of 1972 officially took effect on April 20, 1972.

After the adoption of the TRIPS Agreement, India undertook amendments to the Patents Act of 1970 ('the 1970 Act' or 'the Principal Act'), culminating in the Patents (Amendment) Act, 1999 ('the 1999 Act', the Patents (Amendment) Act), 2002 ('the 2002 Act') and the Patents (Amendment) Act, 2005 ('the 2005 Act'). The Patents (Amendment) Act, 2005 introduced pharmaceutical product patents in India for the first time. This act attempts to balance out the competing interests of a variety of stakeholders, including domestic generic medicine producers, foreign multinational pharmaceutical companies and civil society groups concerned with access to medicines.

PATENT AND TRADITIONAL KNOWLEDGE

Issues related to patents on turmeric and Basmati have been a source of concern and controversy, particularly in the context of intellectual property rights and traditional knowledge. Concerns have been raised about biopiracy, where companies or individuals seek patents on traditional knowledge without proper recognition or benefit-sharing with the communities that have preserved and developed this knowledge.

TURMERIC

In 1995, there was controversy when a US patent was granted for using turmeric powder for wound healing. The Indian scientific community was stirred by the revelation, prompting them to challenge a patent. The Council of Scientific and Industrial Research of India (CSIR) contested the patent, contending that it lacked novelty. They argued that the use of turmeric for healing wounds had long been a traditional practice in India, making it part of the existing knowledge base. The CSIR, acting as the plaintiff, presented a robust case with 832 references, some dating back a century. Notable sources included Ayurvedic healing (1989), the wealth of India (1950), the Indian Materia Medica (1976), the Ayurveda Pharmacopoeia of India (1986), and selected medicinal plants of India (1992). The CSIR effectively demonstrated that traditional

knowledge in India could undermine the novelty required for patent approval, highlighting the significance of Novelty, Non-Obviousness, and Industrial Usage as fundamental criteria for obtaining a patent. The patent was later revoked in 1997 after evidence was presented that turmeric had been traditionally used for this purpose in India for centuries. The case highlighted concerns about granting patents for traditional knowledge and the need for effective systems to prevent the misappropriation of such knowledge.

BASMATI RICE

Similarly, there was an instance involving our Basmati rice. In the 1990s, a US company secured a patent for a strain of rice derived from traditional Indian Basmati. This sparked protests and legal challenges from India, ultimately revoking the patent in 2001. This case highlighted the significance of safeguarding geographical indications and traditional rice varieties. In both situations concerning turmeric and Basmati, broader issues related to intellectual property, traditional knowledge, and the potential exploitation of resources traditionally utilised by communities were brought to the forefront. Steps have been taken to enhance domestic and international legal frameworks, aiming to prevent the unauthorised use of traditional knowledge and ensure that communities reap benefits from the commercial utilisation of their traditional resources.

India is the first country in the world to experiment with a benefit-sharing model that implemented Article 8(j) of UN Convention on Biological Diversity (CBD), in letter and spirit. The Tropical Botanic Garden and Research Institute (TBGRI) in Kerala under Dr Pushpangadan's leadership demonstrated that the indigenous knowledge system merits support, recognition and fair and adequate compensation. The model, also known as 'TBGRI Model' or 'Kani Model' or 'Pushpangadan Model', relates to the sharing of benefits with a forest-dwelling Indian tribal community from whom a vital lead for developing a scientifically validated herbal drug (Jeevani) was obtained by a team of scientists led by Dr Pushpangadan who then functioned as the Principal Investigator and chief project coordinator of an All India Coordinated Project on Ethnobiology (AICRPE) sponsored by the government of India.

George Alfred DePenning (left), the first to be granted a patent in India in 1856, was also the first Patent Agent in the country. Whereas Indian scientist Jagadish Chandra Bose (right) was against the western idea of patents

During the course of an ethnobotanical study on a forest-dwelling tribe namely 'Kani' inhabiting in the southern Western Ghats located in the southern Indian state of Kerala, Dr Pushpangadan and his team came across a unique tribal knowledge on the medicinal use of a lesser known wild plant namely Trichopus zeylanicus war. travancoricus having antifatigue property. He and his team developed a scientifically validated and standardised herbal formulation (Jeevani), which, after necessary pharmacological, toxicological and clinical evaluation released for commercial production in 1996. After the technology transfer of 'Jeevani' to Arya Vaidya Pharmacy (AVP), Coimbatore, TBGRI decided to share 50% of the license fee with the Kani tribe. This mode of benefit sharing is widely appreciated across the globe.

While patents play a crucial role in incentivising innovation by providing a mechanism for inventors to protect and profit from their creations, ethical and societal issues are also associated with the patenting system. Patents in biotechnology raise ethical questions about the ownership of life forms, genetic engineering, and the potential for unintended consequences. The high cost of patented pharmaceuticals can limit access to essential medications, particularly in developing countries. The innovators' race to get more patents raises ethical concerns about the balance between protecting intellectual property and ensuring access to life-saving treatments. There are also concerns on 'patent trolling' or strategic patenting to block competitors from entering a market that may prevent innovation. Finding a delicate balance between encouraging innovation and ensuring that everyone has equal access to knowledge for the benefit of society is one of the ethical issues that must be considered when protecting intellectual property rights.

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YOUNG SCIENTIST: SSB PRIZE 2022 / DR DIPTI RANJAN SAHOO

Reducing the Impact of Earthquakes

Dr Dipti Ranjan Sahoo is co-winner of the prestigious Shanti Swarup Bhatnagar Prize 2022 in the category of Engineering Sciences for developing devices that can minimise the impact of earthquakes on built structures

■ **Science India Bureau**

The Odisha-born engineering researcher Dr Dipti Ranjan Sahoo has been awarded the Shanti Swarup Bhatnagar Prize, 2022 in Engineering Sciences. A professor of Structural Engineering at IIT Delhi, Dr Sahoo has won the prestigious award along with Dr Rajnish Kumar of IIT Madras. They are two of 12 scientists to be awarded the prize, given to scientists below the age of 45 years.

Dr Sahoo has received recognition for creating disaster-resilient, disaster mitigation-related devices that significantly lessen the impact of earthquakes on structures, protecting people and property from natural disasters. He is a fellow of the Indian Society of Earthquake Technology, the Institution of Engineers (India), and the Institution of Civil Engineers (UK). Among the other honours that he has been bestowed with already include the SERB Young Scientist Award, IEI Young Engineering Award, INAE Young Engineer Award, and BRNS Young Scientist Research Award.

Performance-based earthquake design, hybrid simulation and testing, seismic strengthening methods, seismic fragility evaluation, and structural fire engineering are among the study topics of Dr Sahoo. He has filed five patents for seismic vibration control systems and published more than 250 research articles in the fields of earthquake and structural fire engineering.

Dr Sahoo is an Associate Dean (Infrastructure) at the Indian Institute of Technology (IIT) Delhi in addition to being a Professor of Structural Engineering in the Department of Civil Engineering at the university. Dr Sahoo was an assistant professor at IIT Bhubaneswar's School of Infrastructure before moving to IIT Delhi in 2010.

Image Courtesy: Twitter

Dr Dipti Ranjan Sahoo has received the Shanti Swarup Bhatnagar Prize 2022 in the category of Engineering Sciences

Dr Sahoo completed his master's programme in structural engineering at the Indian Institute of Technology (IIT) Kanpur in 2003 after earning his bachelor's degree in civil engineering from the Indira Gandhi Institute of Technology, a division of Utkal University, in Bhubaneswar, in 2001. The institute granted him a doctorate in civil engineering in 2008.

During earthquakes, large buildings and poles sustain greater damage. Four to five technologies have been produced in Dr Sahoo's research to lessen this damage. In the event of an earthquake, devices installed on major buildings and both new and ancient poles can significantly reduce the amount of substantial damage to pillars and buildings. Dr Sahoo has spent nearly a decade in his research on designing earthquake-resistant solutions.

There are three areas of seismic-resilient infrastructure that his group has been focusing on. The creation of energy-absorbing technology is one facet. Using materials that are readily available in the area, Dr Sahoo has created three distinct varieties of these devices, sometimes known as structural fuses. Making them easily accessible and reasonably priced is the aim.

Dr Sahoo's work also involves the application of innovative seismic design techniques and novel materials for

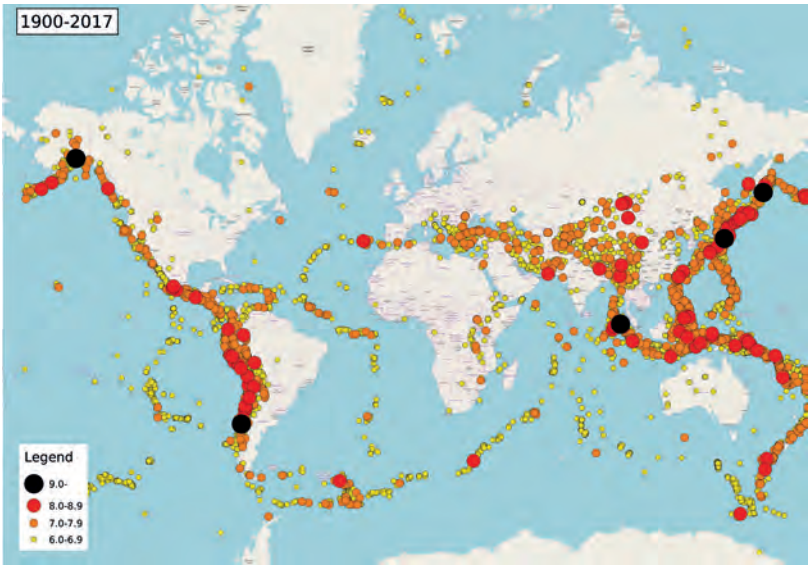


Image Courtesy: Wikimedia Commons

Earthquakes recorded around the world since 1900 through 2017

seismic-resilient infrastructure. Additionally, his team has suggested a performance-based plastic design approach that gives architects the freedom to more easily and quickly build a new structure for a desired seismic intensity level. It also enables them to decide how much it will cost and how long it will take to update currently standing structures that are seismically unsafe.

HOW STRUCTURAL FUSES WORK

These energy-absorbing devices were created to solve an issue with metallic materials, including steel and aluminium, which have a tendency to bow under compression pressure and become useless at withstanding seismic loads. The goal of structural fuses is to maximise the energy-absorbing capacity while limiting such buckling. These devices can be positioned diagonally between member joints, partially filling a panel, or directly underneath a building's beams, depending on the site's limitations.

Dr Sahoo's team has tested prototypes and applied each of the three structural fuse types. It has designed building frames in order to determine how well they work under seismic loads. These devices are not only highly efficient and reasonably priced, but they can be produced and installed on-site. Novel smart materials that are accessible in India have been included into a few of these gadgets.

Making seismic-resilient constructions functional both during and after an earthquake is one of their goals. After an earthquake, structures frequently show deformation, which causes some damage and tilts the structure. In terms of safety, this damage might not be significant, but no one would occupy a structure that is skewed. Dr Sahoo has created self-centering structural systems with intelligent materials that possess the necessary strength, deformability, and re-centering properties to return them to their initial positions. His team has evaluated these materials' mechanical qualities and measured how earthquake-resistant they are in the lab.

Dr Sahoo has created self-centering structural systems with intelligent materials that possess the necessary strength and deformability to return them to their initial positions

The primary basis for the earthquake-resistant design approach currently in use is the lateral force that a building would be subjected to. This technique is predicated on the idea that by guaranteeing specified details, a force-based approach should offer sufficient protection against structural collapse. However, a number of previous earthquakes have demonstrated that this kind of design may not be sufficient to ensure the safety and functionality of significant structures, including hospitals.

However, his research group uses a performance-based design method that offers comprehensive information on the most vulnerable areas that need more care, the level of safety for a given earthquake intensity, and the maximum amount of seismic impact that the structure can withstand while it is still in the design phase.

Dr Sahoo's research also encompasses sophisticated seismic testing techniques, cold-formed steel structures, column-free steel structures, composite hybrid columns, high-strength steel, and more. Six patent applications on passive vibration control devices have been filed so far.

This apparatus has been the subject of numerous experiments. In addition to structures and pillars, laboratories have been used for experiments. In order to test it in earthquake-prone areas, cooperation is also underway. The experiment yielded very positive results. Tests have shown that the devices are capable of handling or minimising large-scale damage during seismic activity. The fact that the experiment's high-intensity earthquakes were controlled is crucial. The experiment's findings make it evident that even in the event of a large earthquake, there would only be slight damage.

The trial period has ended. This technology will be brought into the business shortly. The cost of this technology will vary depending on the size of the devices, and it will be reasonably priced.

Dr Sahoo has authored over 250 research articles in the fields of structural fire engineering and earthquakes.

Campus of National Innovation Foundation-India, Ahmedabad

IN FOCUS: NATIONAL INNOVATION FOUNDATION-INDIA / AHMEDABAD

Nurturing Innovation at Grassroots

NIF-India not just nurtures technological innovation but also empowers traditional knowledge holders to bring an impact on the socio-economic fabric of the country

■ **Science India Bureau**

In a world that thrives on progress, innovation is the driving force that propels societies forward. It's the bedrock upon which civilizations evolve, creating solutions to intricate problems and fostering change. In India, the National Innovation Foundation (NIF)-India stands as a beacon of fostering innovation, creativity and empowering grassroots innovators across the nation.

Against the backdrop of India's rich heritage of traditional knowledge and untapped grassroots innovation, the National Innovation Foundation (NIF)-India was established in the year 2000, and operates as an autonomous institute under the Department of Science and Technology, Government of India. Driven by the visionary guidance of former President Dr APJ Abdul Kalam (2002-2007), and leadership of Dr RA Mashelkar, then Director General of the Council of Scientific and Industrial Research (CSIR), and Dr Anil Kumar Gupta, former Executive Vice Chairperson (NIF) and Professor (IIM-Ahmedabad) envisioned NIF as a hub to identify, recognise, validate, nurture, celebrate, and mainstream the genius of local innovators. NIF embarked on a transformative journey recognizing and harnessing the immense potential of indigenous knowledge and innovations spanning a wide spectrum of domains, from agriculture to healthcare and technology spread across diverse communities in India.

NIF's primary objective revolves around scouting, sustaining, and scaling up grassroots innovations. Its mission encompasses identifying innovators,

All Images Courtesy: NIF, Ahmedabad

providing them with support through scientific validation, intellectual property protection, incubation, and dissemination of their innovations. NIF also focuses on creating linkages between various stakeholders, fostering a culture of innovation, and mainstreaming these inventions through commercial and non-commercial channels for maximum societal impact. Over the years, NIF has expanded its reach and impact, collaborating with various national and international organizations, academic institutions, industry partners, and government agencies to amplify its efforts in nurturing a culture of innovation at the grassroots level.

NIF-India has developed a walker with adjustable legs to climb stairs. The walker has spring-loaded self-locking front legs

INCLUSIVITY IN INNOVATION

At its core, the NIF is dedicated to inclusivity in innovation. One of the most remarkable aspects of NIF's work is its relentless effort in scouting untapped talent. It believes that innovation knows no bounds and can emerge from anyone, irrespective of their background or education. It scouts for ideas from the unlikeliest of places — villages, small towns, and marginalized communities, through an extensive network that traverses the length and breadth of the country. This network, consisting of volunteers, professionals and experts, acts as the eyes and ears of NIF, identifying hidden gems of innovation in the most remote corners of India. Till date, 3,25,000 technological ideas, innovations and traditional knowledge practices from over 625 districts of the country have been scouted and documented by NIF over the last two decades. The NIF also hosts the largest public domain database of 1,39,581 technological ideas, innovations and herbal knowledge. These innovations pertain to various domains such as agricultural machinery, household gadgets, energy, transport, electronics, and communication, general utility, plant varieties, herbal plant protection practices, herbal veterinary practices, among others.

Once an innovation is discovered, NIF extends a helping hand to the innovator by providing appropriate incubation support. From providing technical guidance, scientific validation, mentoring and financial support, it aids in refining and scaling up these innovations. The NIF has recognized and awarded 1144 grassroots innovators and students, and over 2000 technologies have been supported in various forms. As many as 238 projects were supported for working capital through Micro Venture Innovation Fund (MVIF), 120 technologies were licensed and 22 start-ups based on grassroots innovations were registered through its technology business incubator (TBI)- NIFientreC. This support is not just confined to urban areas; it reaches the grassroots, where these innovations hold the potential to transform lives.

PROTECTING INTELLECTUAL PROPERTY RIGHTS

The NIF recognises the importance of protecting intellectual property. It assists these innovators in patenting their innovations and outstanding traditional knowledge based leads, ensuring that they receive their due recognition and benefits for their exemplary work. It has filed 1328 patents in the name of innovators and TK (traditional knowledge) holders, out of which 424 have been granted. Seven trademark applications out of eleven filed and 20 design registrations out of 24 filed have also been granted to grassroots innovators. In order to protect the farmers' varieties developed by grassroots innovators, 81 applications were filed at the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi, out of which 27 have been granted registration. This protection not only safeguards their inventions but also empowers the innovators and TK holders economically.

The impact of NIF's efforts resonates across various sectors. From agriculture to healthcare, from energy to education, the innovations fostered by NIF have touched myriad aspects of daily life. Take, for instance, the story of Subhash Ola, an innovator from Rajasthan who has developed the technology of saving energy in boilers by recycling steam. This innovation won the first prize at the Amazon Sambhav Entrepreneurship Challenge 2022 and his enterprise "Geniusenergy Critical Innovation Private Limited" won the startup of the Year award. His innovation was first developed to make khoya and other milk products, and the portfolio of applications were later extended to textile, milk and food, pharma, plywood, paper mills, leather industry, chemical industry, hot water boiler generator, plastic recycle, laundry, hospitals and so on, showcasing how grassroots innovations can address energy needs sustainably.

Another enterprise incubated by NIF — The Notion Technocrats India, which has developed a low-cost, energy-efficient, environment friendly natural water cooler based on the principle of heat exchange, won the 'Most Promising Grassroots Innovation Startup' award 2022. The enterprise is owned by Arvindbhai Patel from Ahmedabad, Gujarat, who is an innovator turned entrepreneur who manufactures and distributes the Natural Water Cooler.

GRASSROOTS IMPACT OF INNOVATION

Many NIF-supported innovations have brought tangible improvements in society, such as the low chilling apple variety — HRMN-99 — developed by Hariman Sharma that transcended from Bilaspur in Himachal Pradesh to Manipur, Meghalaya, Telangana and Karnataka, providing commercial yields, or the 'Walker with adjustable legs', a student innovation commercialized by VISSCO Healthcare Private limited to innovative agricultural tools reducing manual labour, or healthcare solutions tailored for rural populations, all of which are positively impacting livelihoods. Acquiring BIS standards for grassroots innovations to augment the trade and commerce opportunities, strategic marketing and business development has facilitated Mansukhbhai Prajapati, the innovator of Mitticool products from Gujarat, to export to different countries of the world.

Furthermore, NIF has been instrumental in creating a platform for young innovators through initiatives like the IGNITE Awards (2008-2019) and INSPIRE Awards-MANAK. These awards encourage creativity and problem-solving skills among school children, nurturing the next generation of innovators. Every year, 60 best student innovations selected from the country are incubated and get a chance to showcase their innovation to the President ofIndia at the Festival of Innovation and Entrepreneurship (FINE), a flagship program of NIF celebrating grassroots innovations, held annually at the Rashtrapati Bhawan, New Delhi. The success stories of these grassroots' innovators underline the transformative power of grassroots innovations and the role NIF plays in fostering these ideas. They exemplify how small ideas, when nurtured and supported, can grow into innovative solutions with far-reaching impacts.

Over the years, NIF has expanded its reach and impact, collaborating with various national and international organizations, academic institutions, industry partners, government agencies and other stakeholders to amplify its efforts in nurturing a culture of innovation at the grassroots level. NIF has played a pivotal role in collaborating with the Association of Southeast Asian Nations (ASEAN) and continued its efforts towards deepening relations in science and technology (S&T) through cooperation on the ASEAN-India Innovation Platform, and ASEAN India Grassroots Forum in areas aligned with ASEAN Plan of Action on Science, Technology and Innovation (APASTI). The continual association with Peru, Malaysia, Thailand, and African counterparts — South Africa, Kenya, Zimbabwe, Rwanda — for dissemination of suitable technologies, mentoring support and technological exchanges have been crucial in NIF's evolution. Expanding its network, forging strategic partnerships, and utilizing innovative methodologies to engage with and empower grassroots and scaling of inventive solutions while creating avenues for their integration into mainstream systems is the key to NIF's role in fostering innovation.

NIF-India's mission is to make the country a knowledge-based society by expanding policy and institutional space for grassroots innovators

FACILITATOR OF INDIGENOUS KNOWLEDGE

With its focused approach, NIF stands as a testament to the power of indigenous knowledge and grassroots innovation and has emerged as a critical facilitator in recognizing, nurturing, and mainstreaming grassroots innovations. Its unwavering commitment and endeavours not only empower local innovators but also contribute significantly to the socio-economic fabric of India by fostering a culture of innovation and scientific advancement at the grassroots level. As NIF continues to evolve and expand its horizons, its role in fostering innovation and inclusive growth in India remains indispensable. In essence, NIF's impact on the grassroots innovation ecosystem in India transcends mere recognition. It encompasses empowerment, societal transformation, economic upliftment, and the creation of an environment conducive to continuous innovation and progress.

In conclusion, the National Innovation Foundation (NIF)-India under the auspices of the Department of Science and Technology, stands as a testament to the power of innovation and the spirit of perseverance. Its tireless efforts in recognizing, nurturing, and promoting grassroots innovations have not only transformed lives but have also ignited a spark of creativity that reverberates across the nation. As we celebrate the triumphs of these unsung heroes — innovators who defy conventional norms to make a difference in society — it becomes evident that innovation is not a privilege of a select few but a right inherent in every individual. And organizations like the NIF serve as catalysts, ensuring that this potential is unlocked and harnessed for the greater good of humanity.

ISRO moves Propulsion Module of Chandrayaan-3 from lunar orbit

Indian Space Research Organisation (ISRO) described the Propulsion Module of Chandrayaan-3 as a 'unique experiment' when it was announced that it had been transferred from an orbit near the Moon to one on Earth. "In another unique experiment, like the hop experiment on the Vikram Lander, the Propulsion Module of Chandrayaan-3 was moved from an

Propulsion module of Chandrayaan-3 has been moved from an orbit around the Moon to an orbit around the Earth

orbit around the Moon to an orbit around the Earth," said an ISRO press release. More than a month after the spacecraft's launch, Chandrayaan-3's Vikram Lander achieved a historic landing on the Moon's South Pole on August 23. "The primary objective of Chandrayaan-3 mission was to demonstrate a soft landing near to the lunar South Pole region and perform experiments using the instruments on Vikram and Pragyaan," stated ISRO.

India's top secret Antarctic Mission felt like 'James Bond movie'

Forty years after India established its first scientific base station in Antarctica, the mission's researchers recalled how everyone, including their trainers and families, was kept in the dark about the nation's first journey to this frigid zone. Dr SZ Qasim led a team of 21 scientists on the first Indian research mission to Antarctica, which was set sail in 1981. The voyage had departed from the Goan coast. The nation established Dakshin Gangotri, its first scientific base station in Antarctica, in 1983. "The first scientific

In 1983, India set up its first scientific base station in Antarctica, which was named Dakshin Gangotri

mission from India to Antarctica was a top-secret operation. The highest officials, including the chief of the Navy and cabinet secretaries, attended the initial discussions behind closed doors. We felt like we were in a James Bond movie," said Amitava Sen Gupta, a member of the first expedition.

ISRO activates second instrument on Indian solar spacecraft Aditya-L1

The Aditya Solar wind Particle Experiment (ASPEX) payload onboard India's Aditya-L1 satellite began functioning normally, marking another significant accomplishment for ISRO. The Suprathermal and Energetic Par-

ASPEX payload aboard Aditya-L1 spacecraft has begun functioning

ticle Spectrometer (Steps) and the Solar wind Ion Spectrometer (Switzerland) are the two instruments that make up the ASPEX, according to ISRO. The Swiss instrument was activated on November 2, 2023, and it has performed at its best since then, whereas the Steps instrument became operational on September 10, 2023.

Sudden deaths among young adults not due to Covid vaccine: Study

The Indian Council of Medical Research (ICMR) has concluded in research that the Covid-19 vaccination is not to blame for the inexplicable sudden deaths of young adults in India, while it may lessen the chance of such deaths if at least one dose of the vaccine is given. The study was conducted in the wake of stories of young adults passing away unexpectedly, including well-known Malayalam TV star Dr Priya, who had experienced a sudden heart arrest. Researchers conducted the study because of worries that similar instances of unexpected fatalities among healthy persons in India might be connected to Covid-19 or the vaccine against the illness.

Indian astronaut to fly to Space Station in American vehicle

NASA is aiming to send an Indian astronaut to the International Space Station (ISS), according to ISRO Chief S Somanath, which is a major step forward for India's space goals. Bill Nelson, the head of NASA, remarked while on an official visit to India. Prime Minister Narendra Modi and US President Joe Biden originally discussed the issue at a senior level. Astronauts are currently being sent to the International Space Station (ISS) by

All Images Courtesy: Internet

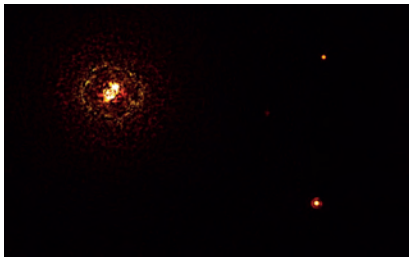
ISRO Chief S Somanath confirmed that NASA is working on sending an Indian astronaut to space

NASA utilizing SpaceX, which is run by Elon Musk, and its Falcon-9 rocket. "We are taking it forward; that's what the Nasa chief said — that Indian astronauts will be flying to the international space station in an American vehicle," said Somanath.

Planet 100 times bigger than its Sun discovered

Researchers have discovered a large planet circling a red dwarf star, which are frequently seen in the Milky Way galaxy. The planet, identified as LHS 3154 b, has at least 13 times the mass of Earth and revolves around a star

All Images Courtesy: Internet



The planet, named LHS 3154 b, is at least 13 times the mass of Earth

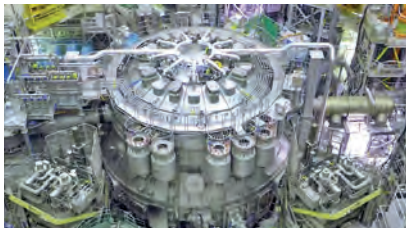
that is only 11% as big as our sun. This has led scientists to re-evaluate their assumptions regarding the formation of planets surrounding tiny stars. The newly discovered planet's mass ratio and its star's mass ratio are almost 100 times larger than the Earth's and the Sun's, according to research led by Penn State astronomer Suvrath Mahadevan. This discovery is especially unexpected because it was previously believed that red dwarfs, which are much smaller and less bright than our sun, could not support massive planets.

Webb Telescope's remarkable finding on rise of Earth-like planets

Astronomers have seen water and other essential chemicals for the first time inside a protoplanetary disc situated in one of the harshest conditions in the galaxy, thanks to the James Webb Space Telescope (JWST). This finding contradicts earlier theories regarding the environments in which rocky planets might form, indicating that these processes may not just take place in the peaceful nurseries of low-mass stars but may also take place around big stars and in a greater range of cosmic contexts. The results come from the eXtreme UV Environments (XUE) study, which analyzes planet-forming disks in regions dominated by big stars, utilizing JWST.

World's largest nuclear fusion reactor mimics the Sun

The largest functioning experimental nuclear fusion reactor in the world has been unveiled by Japan. This enormous device, known as the JT-60SA, is kept in a hangar in Naka, north of Tokyo, and marks a turning point in the search for clean, endless power. Nuclear fusion, which resembles the



JT-60SA, the world's largest nuclear fusion reactor, is housed near Tokyo

sun's energy generation by fusing two nuclei, may be a safer and more plentiful energy source than the conventional nuclear fission employed in power plants, which splits atomic nuclei.

Earth to get warmer by 1.4°C by year end

As the year 2023 draws to a close, the World Meteorological Organization (WMO) has issued a grim warning: The world is on course to have the warmest year on record. With global temperatures rising to around 1.4°Celsius over pre-industrial levels, the World Meteorological Organization's preliminary 'State of the Global Climate' report highlights an alarming pattern of accelerating climate change.

The gravity of this temperature rise cannot be emphasized. It outperforms the previous record established in 2016, indicating a "deafening cacophony" of broken climate records.

Unusual volcanic glass object discovered off Italian coast

The cargo of an old ship has been discovered in the Bay of Naples by Italian police. Archaeologists believe the relics date back to the Neolithic period. The obsidian (volcanic glass) sample was discovered in October by the Naples Police Underwater Squad, which handed it over to scientists. The artifacts were discovered at a depth of 130 feet near a sea cave, according to the report, which cited the Naples Metropolitan Area's Superintendency of Archaeology, Fine Arts, and Landscape (SABAP).

Mysterious white lung syndrome spreads globally

A new type of bacterial pneumonia known as White Lung Syndrome is wreaking havoc on children in China, Denmark, the United States, and the Netherlands. The sickness primarily

The mysterious pneumonia is primarily affecting children in China, US, Denmark and the Netherlands

affects youngsters between three to eight years old. White lung syndrome pneumonia is caused by bacteria mycoplasma pneumoniae that many medications cannot treat. The mystery pneumonia cases in children are reaching 'epidemic levels' in Denmark, with terrifying parallels to the coronavirus origins. The Netherlands has also reported an alarming increase in the number of youngsters with pneumonia, and Sweden is also affected.

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Radiative Paint to Cool Buildings

This affordable radiative paint, developed at JNCASR, Bengaluru, can reduce electricity consumption for cooling buildings, especially challenging in Indian summers

■ **Science India Bureau**

The increasing effects of urban heat island and global warming have made cooling technologies essential to human existence. But air conditioners, electric fans, and refrigerators are examples of active cooling appliances that use a lot of electricity. A significant amount of greenhouse gases are released by active cooling devices, which increase the Earth's surface temperature in addition to their high energy consumption.

A new low-cost, environment friendly radiative cooling paint designed to efficiently cool buildings, pavers, and tiles in hot weather can save electricity use and provide much-needed comfort on scorching summer days.

In order to overcome the obstacles created by conventional cooling devices, radiative cooling technology uses no power and produces cool surfaces by directly radiating heat radiation through the atmospheric transmission window (8–13 μm) to the cold universe (around 3K). Because of this, passive daytime radiative cooling, or PDRC, has attracted a lot of attention lately for a variety of applications, including solar cells, pavers, tiles, building and vehicle cooling, and personal thermal management.

A novel radiative cooling paint has been developed by a team of researchers at the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) in Bengaluru, comprising Dr Bivas Saha, Prasanna Das, Sourav Rudra and Krishna Chand Maurya. With a high solar reflectivity and infrared thermal emissivity, this low-cost, solution-processed paint has notable cooling characteristics. It was developed from a unique MgO-PVDF polymer nanocomposite.

Scientists at JNCASR, an independent institute of the Department of Science and Technology, conducted experiments that revealed that in direct sunlight, the surface temperature of a treated paver drops by about 10°C — nearly twice as much as that which is achieved with traditional white paints.

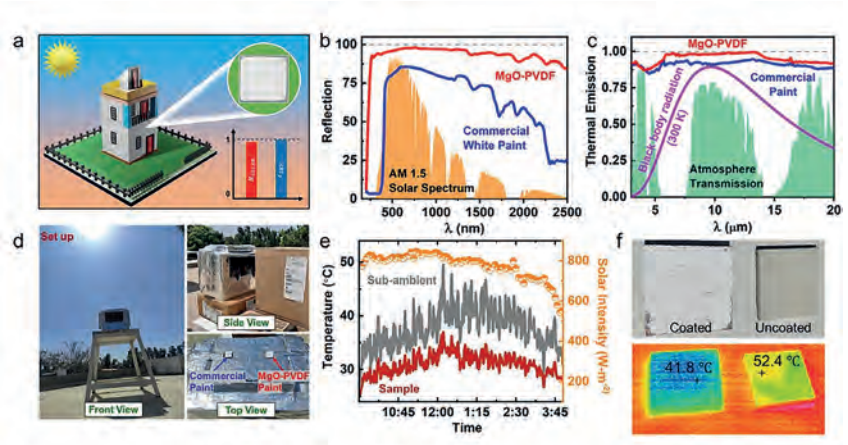

Image Courtesy: JNCASR

(a) Schematic of building painted with radiative cooling paint (b) Reflection spectra of MgO-PVDF coating and a commercial white paint along with AM1.5 solar spectrum (c) Thermal emission spectra of MgO-PVDF composite film, commercial paint, blackbody (BB) spectrum at 300K, and atmospheric transmission profile (d) Photo of radiative cooling measurement setup employed for the field test on a flat roof in Bangalore (e) The outdoor real-time cooling results of the MgO-PVDF coating with respect to sub-ambient (f) Photo and thermal image of a coated and an uncoated ceramic paver outdoors

The researchers used a straightforward solution-processed method to create paint made of polymer nanocomposite. They employed a magnesium oxide (MgO)-polyvinylidene fluoride (PVDF) nanocomposite, which is extremely white and emissive and is made of inexpensive, readily available, nontoxic, and non-harmful ingredients. First, a solvent was used to turn the powdered polymers into a solution, and then the dielectric nanoparticles were scattered throughout the polymer matrix. Following preparation, the optical characteristics of the polymer nanocomposite paint were assessed using several spectroscopic techniques. Excellent cooling performance was proved in the hot sun by employing a thermocouple to measure the paint's temperature.

Due to MgO bond vibrations and other stretching/bonding vibrations from the polymer, the optimized MgO-PVDF with dielectric nanoparticles produced a large solar reflectance of 96.3% and a record high thermal emission of 98.5%. The water-resistant hydrophobic properties of the nanocomposite paint allowed it to be applied with high uniformity and good adhesion to surfaces such as pavers and wood sticks.

"Our creative research has produced an affordable, environmentally friendly paint that can lower surface temperatures (such as those of buildings, tiles, pavers, etc.) by more than 10°C on hot summer days. We see this paint providing substantial relief from the summer heat with its easy application, which will help both rural and urban areas," said Dr Bivas Saha of JNCASR.

The work, published in the Wiley publication Advanced Materials Technologies may encourage the building and construction industries to use radiative cooling paint.

Quiz: Laws of Nature

1. How many laws of Kepler's planetary motion are there?
A. 5
B. 7
C. 3
D. None of the above

2. The only living reptile that use a vertical limb posture in walking is:
A. Lizard
B. Crocodile
C. Snake
D. None of the above

3. Of these trees, which one is considered a living fossil?
A. Cycas
B. Lady fern
C. Ginkgo
D. None of the above

4. The ability of a substance to permanently change its shape in reaction to stress is known as:
A. Reflectivity
B. Elasticity
C. Ductility
D. None of the above

5. Which technological advancement was the first of the following?
A. Telephone
B. Telegraph
C. Telescope
D. None of the above

6. Which of these laws states that there is a direct proportionality between voltage and current?
A. Ohm
B. Coulomb
C. Faraday
D. None of the above

7. What kind of material causes the blue tint on litmus paper?
A. Alkali
B. Acid
C. Base
D. None of the above

8. Who was the recipient of the first Nobel Prize for Physics?
A. Marie Curie
B. Albert Einstein
C. W C Rontgen
D. None of the above

9. In the periodic table, which elements make up group 18?
A. Alkali metals
B. Noble gases
C. Halogens
D. None of the above

10. Who made the discovery of white light's composition?
A. Isaac Newton
B. Galileo Galilei
C. Stephen Hawking
D. None of the above

Enrich Yourself With Facts On ISRO's 12 Missions In 2024

■ In the next two years, the Indian Space Research Organization (ISRO) plans to launch an impressive array of space missions with an emphasis on innovation, communication, and exploration.

■ ISRO has outlined a roadmap with 12 major missions that will push the limits of India's space capabilities as 2024 draws near.

■ The NASA-ISRO Synthetic Aperture Radar (NISAR), an initiative combining NASA and ISRO, is one of the most eagerly awaited missions.

■ The first dual-band radar imaging satellite, Nisar will deliver vital information for Earth observation. The increasing level of international cooperation in space exploration is highlighted by this mission.

■ One of the key components of the Indian National Satellite System series, which is essential to meteorology and disaster management, is the communication satellite INSAT-3DS.

In the next two years, ISRO plans to launch an impressive array of space missions

■ Resourcesat-3 and RISAT-1B are expected to improve India's remote sensing capacity.

■ To advance lunar missions, TDS01 and SPADEX will conduct additional technological experimentation and research.

■ Oceansat-3A will carry on the oceanography and atmospheric research legacy of its forerunners. Establishing a real-time communication link with scientific and remote sensing satellites is the goal of the Indian Data Relay Satellite System (IDRSS).

■ It is anticipated that NVS-02 will improve navigation systems and GSAT-20 will support telecommunication services.

■ ISRO is planning test flights that will eventually result in the launch of Indian astronauts into space as part of the Gaganyaan Programme, in addition to considering unmanned missions.

■ This project will launch India's human spaceflight programme, a momentous occasion for the country. The RLV program also aims to showcase technologies for affordable space access.

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

Arvind Gupta
(Indian Toy Inventor and Scientist)

Image Courtesy: Wikimedia Commons

"The idea is to show the kids how they can reuse trash and make something valuable and extremely delightful without buying anything"

— Arvind Gupta on his goal

December
2023

Celebrating Science This Month

DECEMBER 1
World AIDS Day is observed every year to raise awareness and knowledge about HIV. It was first observed in 1988.

DECEMBER 2
National Pollution Control Day is observed in the memory of the people who lost their lives in the Bhopal Gas Disaster on the night of 2 December 1984.

DECEMBER 3
Jayakrishna Indraji, who wrote the first botanical treatise following Hooker's classification, passed away on 3 December 1929.

DECEMBER 4
Arvind Gupta, the Indian toy inventor and expert in science, was born on 4 December 1953. His first book, *Matchstick Models and other Science Experiments* is widely translated.

IISF 2015 (Indian International Science Festival) was held from 4 to 8 December at IIT, New Delhi.

Indian physicist Sir Kariamanikkam Srinivasa Krishnan was born in 1898. He was a co-discoverer of Raman scattering, for which his mentor, Sir CV Raman was awarded the 1930 Nobel Prize in Physics.

DECEMBER 7
Indian International Science Festival (IISF) 2016 was held from 7 to 11 December at National Physical Laboratory, New Delhi.

DECEMBER 9
Indian Veterinary Research Institute was established in 1889 as Imperial Bacteriological Laboratory at Pune; it was later shifted to Mukteshwar (Uttarakhand).

DECEMBER 10
Sir CV Raman received Nobel Prize in Physics in 1930.

DECEMBER 11
RISAT-2BR1 was launched in 2019 to provide services in the field of Agriculture, Forestry and Disaster Management.

DECEMBER 13
Ahmedabad Textile Industry Research Association was established in 1947. It is the largest association for textile research & allied industries in India and started functioning in 1949.

INS Arihant was acquired in 2014.

DECEMBER 14
National Energy Conservation Day is observed annually.

INS Kalvari (S-21) was commissioned into the Indian Navy by the Prime Minister Narendra Modi in 2017. It is the first of the six Scorpene-class submarines built under Project 75 (Kalvari Class).

DECEMBER 17
The Indian Statistical Institute was founded in 1931 and housed in the Statistical Laboratory, which in turn was established by PC Mahalanobis as the Statistical Laboratory in the Presidency College in 1920s.

DECEMBER 18
Crew Module Atmospheric Re-entry Experiment (CARE) was launched in 2014. Crew Module (CM) is identified as the payload in GSLV MK-III-X/CARE Mission.

DECEMBER 19
GSAT-7A was launched in 2018. It is the 35th Indian Communication satellite built by ISRO.

Upendranath Brahmachari, who synthesised Urea Stibamine in 1922 and determined that it was effective in the treatment of Kala azar, was born in 1873.

DECEMBER 22
Srinivasa Ramanujan was born in 1887. This mathematician's contributions to the theory of numbers include pioneering discoveries of the properties of the partition function. His birth anniversary is celebrated annually as National Mathematics Day.

DECEMBER 23
Visva Bharati University was established in 1921. This Institution of National Importance in Santiniketan was founded by Rabindranath Tagore.

DECEMBER 25
Cotton scientist Chandrakant T. Patel died in 1990. Patel developed the first commercial cotton hybrid, known as Hybrid-4 (Sankar-4), in 1970, which was later cultivated commercially in the states of Gujarat and Maharashtra.

DECEMBER 29
National Institute of Occupational Safety and Health was established in 1970. Also known as Statens arbeidsmiljøinstitutt or STAMI, it is a government body organized by the Norwegian Ministry of Labour and Social Inclusion.

DECEMBER 30
Vikram Sarabhai, father of Indian space programme, passed away in 1971. He initiated space research and helped develop nuclear power in India.

All India Institute of Hygiene and Public Health (AIIH&PH) was established in 1932 in Kolkata. It is a pioneering institute for research and training in public health and allied sciences.

DECEMBER 31
Indian Cancer Research Institute was founded by Prof VR Khanolkar in 1952.

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- IISF Challenge
- Education for Aspiring India-National Science Teachers Workshop
- Young Scientists' Conference
- New Age Technology Show
- National Social Organisations and Institutions Meet (NSOIM)
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