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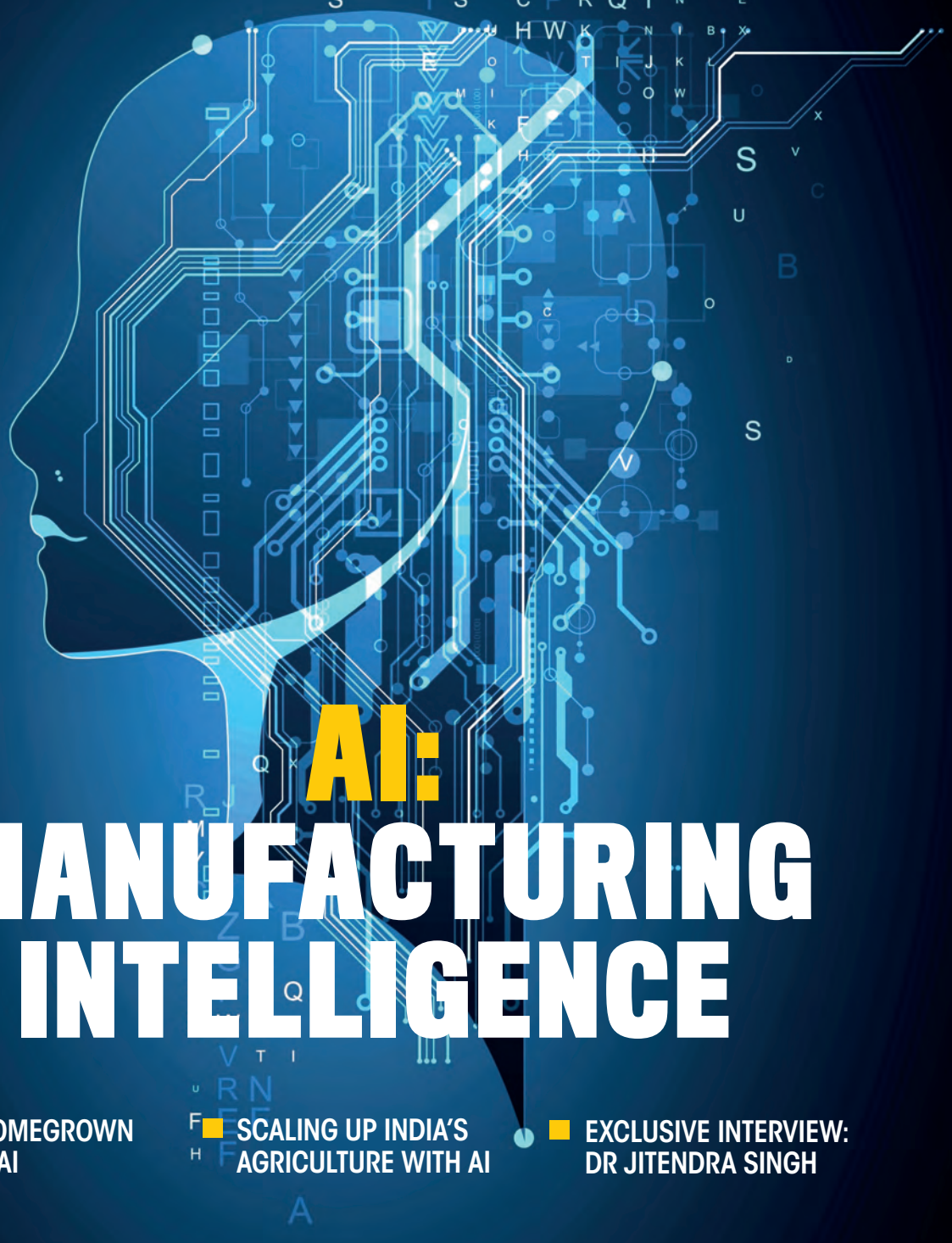

AI: MANUFACTURING INTELLIGENCE

- KRUTRIM, HOMEGROWN FORAY INTO AI
- SCALING UP INDIA'S AGRICULTURE WITH AI
- EXCLUSIVE INTERVIEW: DR JITENDRA SINGH

Gujarat Biotechnology Research Centre

Department of Science and Technology
Government of Gujarat

Tackling Societal Problems Through Biotechnology

About GBRC

Gujarat Biotechnology Research Centre (GBRC) was established in 2017 by DST, GoG to conduct biotechnology research in state priority areas with the ideology of 'Vigyanam Brahmah' aims to set up centres of excellence, specialized laboratories and units with a specific objective of facilitating biotechnology research and development independently or in collaboration with any agencies, institutes, organizations, individuals, industries, Government and Non-Government bodies of state as well as national and international level.

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- Development of National & International collaborations.

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- Genomic Selection Network for Dairy Cattle and Buffalo Breeds in Gujarat
- UKRI-GCRF funded One Health Poultry Hub
- Genome India Initiative
- Network Program on AMR, Superbugs and One Health
- Panchkarma, an ancient ayurvedic treatment rheumatoid arthritis through Biotechnology

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What's Inside

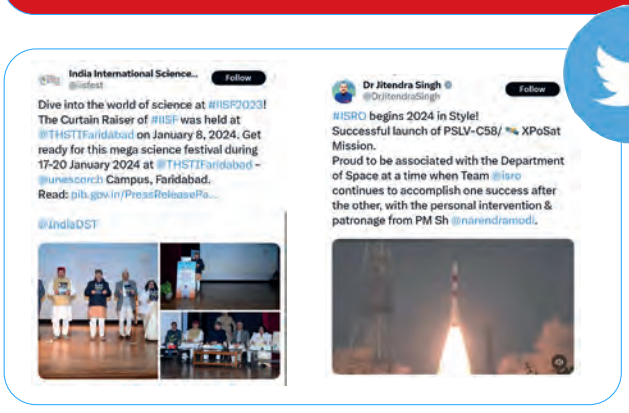
Image courtesy: Shutterstock

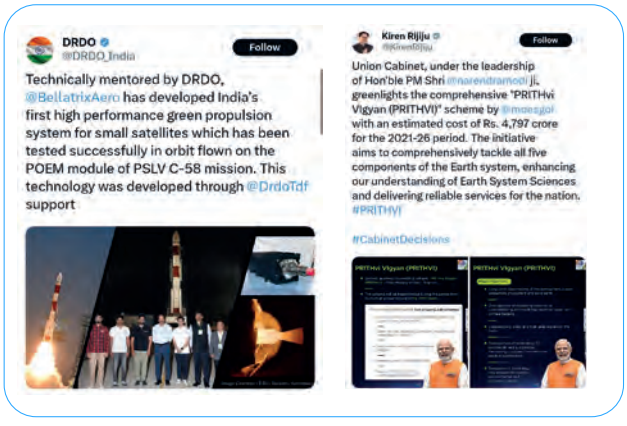
10-24 **As we wrap our heads around AI, this package decodes its multifarious aspects — its potential, pitfalls, the works**

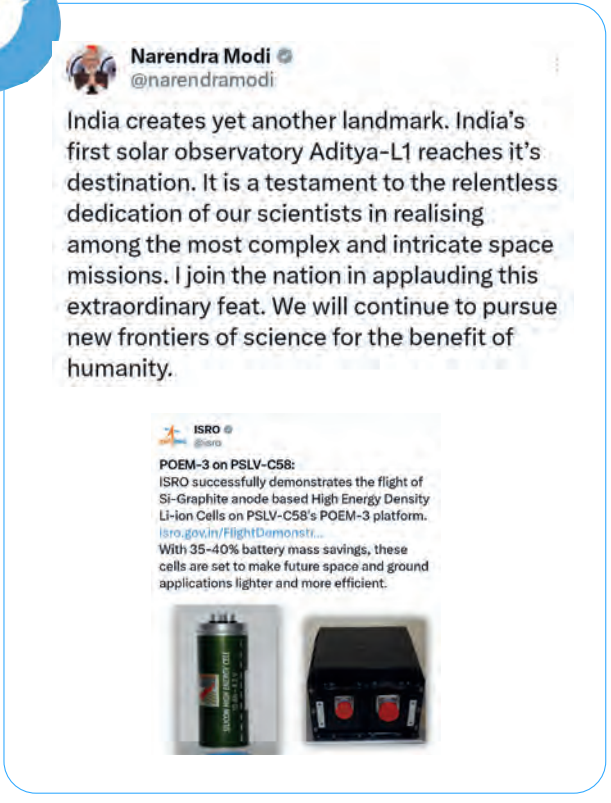
Cover image courtesy: Shutterstock

SCIENCE INDIA WEB PORTAL LAUNCHED

Union Minister of State (independent charge) for Science & Technology, Dr Jitendra Singh launching the web portal of *Science India* magazine, published by Vijnana Bharati (VIBHA). Present on the occasion were Dr Shiv Kumar Sharma, national organising secretary, VIBHA, Praveen Ramadas, national joint organising secretary, VIBHA, and other officials, along with the editorial team of *Science India*.







INDIA INTERNATIONAL SCIENCE FESTIVAL (IISF) 2023

DATE: January 17 - 20, 2024
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

Send your letters to editor@scienceindia.in

Let's Connect

Dear Readers,

January is the auspicious month of the festival of Makar Sankranti and team *Science India* wishes its readers warm greetings on this festival of 'transition'. This festival signals an astronomical transition (Sankranti), i.e., the entry of the Sun into the zodiac sign of Capricorn (Makar). This transition marks the journey of the Sun towards the northern hemisphere, heralding the termination of winter — from this day onwards, the days start getting longer while nights start getting shorter. This northward turn of the Sun has given another beautiful name to this festival — Uttarayan. This astronomical phenomenon unleashes immense changes on the cycle of life on the earth, such as the harvest season. It is celebrated across the country through festivals such as Bhogali Bihu in Assam, Lohri in Punjab, Pongal in Tamil Nadu, and of course, as Makar Sankranti in a major part of India. All these festivals developed in India over the course of centuries through scientific analysis of natural phenomena, pointing to the scientific basis of our festivals, and the desire of our ancestors to live in harmony with nature for sustainable life.

This month, the nation will celebrate another festival, the ninth edition of the India International Science Festival (IISF), which is being held from January 17 to 20 at Faridabad. It is a collaborative effort between the Ministry of Science and Technology, Ministry of Earth Sciences, National Innovation Foundation and Vijnana Bharati. It is a salute to science and to the ever-expanding science movement of the country.

In fact, the year gone by will be remembered for all times to come for the superlative achievements of the Indian scientific community, at the zenith of which lies the successful Chandrayaan-3 mission. The significance of the successful mission is immense in the immediate terms and for the scientific community, but its real importance lies in unleashing a spirit of research amongst the younger generation that will, no doubt, give birth to brilliant scientists in future.

After all, Chandrayaan-3 has been billed as *numero uno* among the biggest science stories on 2023.

'While western billionaires were busy sending rockets to space only for them to crash and burn, scientists in India were quietly doing something no one had accomplished before. Their Chandrayaan-3 moon lander was the first mission to reach the lunar south pole – an unexplored region where reservoirs of frozen water are believed to exist. I remember my heart soaring when images of the control room in India spread around social media, showing senior female scientists celebrating their incredible achievement.'

More than ever before, science now truly occupies the central position in our lives. The buzz word of contemporary times, Artificial Intelligence or AI, is the biggest proof of that fact

These were the words of Haley Gomez, a professor of astrophysics at Cardiff University, who wrote about India's Chandrayaan-3 mission in *The Guardian* story, *The 10 biggest science stories of 2023 – chosen by scientists* that gave it the top billing. While we don't need any validation from the West for who we are and what we are worth, Gomez is quoted simply because it succinctly sums up the magnitude of India's achievement with Chandrayaan-3, whose enormity is not lost on scientific leaders of the world, most of whom are, incidentally, western.

More than ever before, science truly now occupies the central position in our lives. The buzz word of contemporary times, Artificial Intelligence or AI, is the biggest proof of that fact. The most oblivious of us are now using AI in our daily lives, without even realising. So, what is AI? We decode different layers of the topic in this edition's cover story, which is a package the team hopes readers will thoroughly enjoy, as it not only covers AI, but also other aspects of AI in India from indigenous 'Krutrim' to agriculture and diplomacy.

This edition also carries an insightful and exclusive interview with the Union Minister of State (Independent Charge) for Science and Technology, Dr Jitendra Singh, who spoke to *Science India* at the launch of the magazine's web portal recently. Supplemented with our regular columns, this edition packs a punch, and we hope you will savour it in the Gregorian New Year.

■ Dr Pallavi Somvanshi

To Fear or Not to Fear: Insights into 'Variant of Interest' COVID-19 JN.1

Though the symptoms of this COVID-19 variant are moderate, preventive measures are critical and people are advised to follow protocol of wearing masks and keeping hands clean, among others

As rightly said, 'A man is a product and producer of his environment,' as are the microbes. Microbes serve as silent warriors with notable impacts on the world of science. On the contrary, quantifiable levels of changes in the genome composition of such tiniest organisms (mainly viruses) will pose a threat to society. The world population faced such a threat in December 2019 with COVID-19, which prompted extensive and unprecedented lockdowns, unrest, and travel restrictions. Despite proper government regulations and the availability of immunisation globally, the emergence of Delta and Omicron variants is documented worldwide. Erstwhile only genetic and aerosol transmission were considered responsible for COVID-19 while surveillance case study reported by Kolluru and team deduces air pollution as a silent agent in increasing COVID-19 cases. Therefore, manual interventions in the genetic complexity give rise to uncontrollable pandemic situations, whereas environmental factors also result in the prevalence and emergence of novel viral strains.

Accordingly, a novel COVID subvariant, JN.1 (popularly considered a 'variant of interest'), was recognised by the World Health Organisation in December 2023. The JN.1 (BA.2.86.1.1) variety, which is descended from the SARS-CoV-2 BA.2.86 lineage (Pirola), first appeared in late 2023. The circulating SARS-CoV-2 Omicron XBB lineages, such as EG.5.1 and HK.3, are phylogenetically distinct from the BA.2.86 lineage, originally discovered in August 2023. According to the reports, the Indian SARS-CoV-2 Genomics Consortium (INSACOG) discovered this subvariant on December 16, 2023, in a 79-year-old woman. As of December 28, 2023, a total of 109 JN.1 COVID variant cases were reported in India. As per the Health Ministry, the majority of cases are reported in Gujarat, Karnataka, Goa, Maharashtra, Kerala, and Rajasthan, and home isolation is suggested for the patients. The genome sequencing confirms the presence of the first case of the JN.1 subvariant in Delhi. A direct link between air pollution and COVID-19 cases is discussed by several researchers worldwide, which in turn suggests the silent role of pollution in increasing cases of COVID-19. For instance, exposure to pollutants is associated with oxidative stress and inflammation, two conditions that can exacerbate a person's body's reaction to any virus, including the coronavirus.

VARIANT OF INTEREST

Notably, According to VK Paul, a NITI Aayog member for health issues, despite

Image Courtesy: Shutterstock

Maintaining basic health protocol such as wearing masks is the key to prevent infections

BASIC FACTS ABOUT JN.1

- JN.1 is a sub-variant of Omicron, which means it has evolved after mutation in Omicron strain of SARS-CoV-2 virus. This new mutation has occurred in the spike protein which makes JN.1 evade immunity achieved by previous vaccination/ natural infection.
- It has a much higher transmissibility rate as compared to Omicron, which implies it can infect a larger number of people than Omicron.
- Common symptoms of infection include cough, runny nose, sore throat, body aches, and fever, which can be high grade. Headaches have also been reported.
- Some critical symptoms include breathing difficulties and gastrointestinal issues.
- Severity of symptoms could worsen due to underlying conditions such as diabetes, cholesterol, stress, cancer, autoimmune diseases, etc.
- People with previous COVID infections should be more careful to prevent further damage to lungs.
- To curb the spread of infection, experts advise adhering to all necessary precautions, such as washing hands regularly and wearing masks.
- Reverse isolation is equally important — people who are ill should avoid stepping out of the house or attending gatherings in closed spaces, and if they cannot avoid that, they should wear a mask to protect others from catching infection.

the recent spike in COVID-19 cases connected to the JN.1 strain, there hasn't been a commensurate rise in severe instances. The majority of those infected with this variant have moderate symptoms like fever and cough. Moreover, Soumya Swaminathan (former chief scientist at WHO) also emphasised the need to stick to the recommended preventative measures because the virus features haven't changed all that much. JN.1 has been classified by the World Health Organisation (WHO) as a variant of interest; as opposed to a variant of concern, meaning that while it still has to be monitored closely, there is presently no reason for concern. JN.1 does not appear to be linked to an increase in instances of severe illness or symptoms that are different from those linked to earlier strains, while there is not enough data to draw any firm conclusions yet. The majority of COVID symptoms are comparable across variations, and the degree of the symptoms usually depends more on the individual immunity than the variation. In accordance, a close view of the occurrence of novel mutations, intensity, discernible change in symptoms, and hospital admissions should be maintained. Rather, the severity and symptoms of COVID-19 are generally constant amongst variations, but the host's immunological responses also play a major role in disease potential.

FIRST LINE OF DEFENCE

The Centers for Disease Control and Prevention (CDC) reported that symptoms, viz., body ache, diarrhea, fever, runny nose, and difficulty in breathing are common among all COVID variants but severity depends on the individual's immunity and other prevailing diseases. Based on recent past trends, the CDC predicted a rise in COVID-19 and other respiratory illness cases this autumn and winter. The CDC has emphasised that antiviral therapies should continue to be effective against JN.1 and other variants and that COVID-19 testing should be able to identify them.

This emphasises how crucial vaccination is as the first line of defense against JN.1 and all other virus strains. Because of the ongoing threat posed by the COVID-19 pandemic and its variations, preventive measures remain critical. People should keep up with routines such as wearing protective masks in confined spaces, thoroughly cleaning their hands, and keeping up-to-date immunisation records. This is particularly critical for those who have a higher risk of developing serious illnesses. It is important to emphasise that these precautions are effective not only against JN.1 but also against a wider range of SARS-CoV-2 genotypes. We should keep implementing a strong emphasis on preventive measures like mask usage, hand washing, and immunisation when fighting COVID-19 and its variants. In addition, the emergence of novel respiratory diseases complicates the public health landscape and necessitates the development of an all-encompassing global health strategy. Moreover, research on the interlinks of pollution to the spread and prevalence of COVID should be discovered for both elements.

**The writer is Associate Professor, School of Computational & Integrative Sciences (SC&IS), Jawaharlal Nehru University, New Delhi.*

XPoSAT: ISRO's First Mission to Study Black Holes Lifts Off

XPoSAT is India's gift to X-ray astronomers of the world who will be the primary users of data generated by this space-based telescope

■ Sonam Singh Subhedar

PSLV-C58 vehicle placed the satellite precisely into the intended orbit of 650 km with 6-degree inclination

In an effort to unravel one of the oldest mysteries of the universe — black holes — India launched a new mission on New Year's Day. On January 1, the XPoSAT, or X-ray Polarimeter Sat, was launched by the Indian Space Research Organisation (ISRO) at 9.10 am. That makes India the second nation after the US to have a specialised 'observatory' for studying black holes.

The launch of the XPoSAT mission also signified the Polar Satellite Launch Vehicle's (PSLV) 60th flight. The 260-tonne rocket carries an advanced astronomy observatory. XPoSAT will assist in the study of radiation from nearby black holes and neutron stars by employing X-ray photons and their polarisation. POLIX (Polarimeter Instrument in X-rays) and XSPECT (X-ray Spectroscopy and Timing) are its two payloads.

Prof Chaitanya Giri, Associate Professor of Space Strategy and Policy at FLAME University, Pune, who was a crew member of the European Space Agency's Rosetta Mission to comet 67P/Churyumov-Gerasimenko, told *Science India*, "One of the biggest achievements of XPoSat mission is that it is an undertaking of the Department of Science and Technology's Raman Research Institute in cooperation with ISRO. Space based astronomy is the forte of non-ISRO institutions, be it Astrosat, Aditya-L1, or XPoSat, all have been largely a result of institutions like Inter University Centre for Astronomy and Astrophysics, RRI, Indian Institute of Astrophysics, and IISERs along with numerous state and central universities. IIT Bombay, too, is currently designing the Daksha mission to study high energy sources in the universe. Astronomy is among the most internationalised scientific domains; Bharatiya scientists have tremendous professional network all across the world, and the immense amount of experience and knowledge comes into play in designing such missions. Multilateral platforms like the BRICS Astronomy Group, the International Astronomical Union, or the United Nations Office for Outer Space Affairs have helped create solid scientific knowledge exchange platforms helping scientists from both developed and developing economies. Each country, including those in the Global South, has a unique vantage point to the skies, and this vantage has helped astronomical sciences to proliferate."

Using the POLIX payload, the satellite will use Thomson Scattering to measure the polarisation of X-rays in the 8–30 keV energy range that are emitted by roughly 50 possible cosmic sources.

Long-term spectral and temporal studies of cosmic X-ray sources will be conducted by XPoSAT. Additionally, using the POLIX and XSPECT payloads, it will perform spectroscopic and polarisation measurements of X-ray emissions from cosmic sources.

"X-ray astronomy, the bedrock of XPoSat is not possible from ground based telescopes due to attenuation of X-rays as they enter Earth's dense atmosphere. It demands space based telescopes. Bharat's efforts with XPoSat will be cherished by X-ray astronomers from all across the world as they will become the primary users of the data this space-based telescope will generate. XPoSat is Bharat's gift to the X-ray astronomers of the world." Prof Giri added.

Black holes have the highest gravitational force in the universe, and neutron stars have the highest densities. Gathering more information on this, the mission will help unravel mysteries of ultra-extreme environments in space.

**The writer is Associate Editor, Science India.*

Image Courtesy: ISRO

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COVER STORY

Artificial Intelligence: Outsourcing Human Brain

With AI or Artificial Intelligence enveloping human life from all sides, and set to bring a paradigm shift in the journey of our civilisation, it's time we understood this new entity, its gifts, powers, disadvantages and even dangers inherent in its being

■ Dr Rajnish Kumar

ChatGPT, AI, Sam Altman, Krutrim… these are words and names that most of us using the internet today are familiar with even though we may not be able to tell exactly what or who these are. Of all the legacies of 2023 that will continue to inform and massively affect our lives this year and for all the years to come, it will be AI or Artificial Intelligence, much more than the geo-political issues such as the Russia-Ukraine war, the petrol prices, Israel-Hamas conflict, etc. AI, in fact, reached peak human curiosity through April 30 and May 6 last year with the term earning the maximum 100 points on the internet search. With the world increasingly finding itself wrapped around with AI in some or the other way, it's imperative that we decode it threadbare and understand how it is going to govern our lives in future.

WHAT IS AI?

Artificial Intelligence (AI) is a branch of computer science that focuses on creating systems or machines that can perform tasks that typically require human intelligence. One can imagine AI as the brainpower behind smart devices, allowing them to think and make decisions on their own. In essence, AI seeks to imitate human cognitive functions, such as learning, reasoning, problem-solving, perception, and language understanding to enable machines to emulate human-like intelligence, making them adaptable and capable of handling diverse tasks. AI operates through algorithms, which

Image Courtesy: Shutterstock

are sets of instructions that guide the machine in processing information and making decisions. The algorithms are like recipes that tell the machine what steps to take based on the input they receive.

Machine learning, a subset of AI, is particularly fascinating. It involves feeding machines with vast amounts of data and allowing them to learn and improve their performance over time without explicit programming. One popular form of machine learning is neural networks, inspired by the human brain's structure. Neural networks consist of interconnected nodes that process and transmit information. Through training, where the system is exposed to various examples, the neural network adjusts its connections to recognize patterns and make predictions.

Another essential aspect of AI is natural language processing (NLP), which enables machines to understand and respond to human language. This is what powers virtual assistants like Siri or Alexa — they comprehend the voice commands and respond accordingly.

AI has the potential to bring about a significant paradigm shift in human civilization, akin to the impact of the IT revolution. While the IT revolution transformed how we communicate, work, and access information, AI can revolutionize how we process information, make decisions, and interact with technology. AI technologies, from healthcare to finance and daily conveniences like virtual assistants, are transforming human lives by enhancing diagnostics, personalizing treatments, improving fraud detection, and providing adaptive learning experiences. From autonomous vehicles to entertainment, AI's pervasive influence is reshaping various industries and daily activities. The ability of AI systems to learn from data and adapt without explicit programming holds promise for solving complex problems and improving efficiency across multiple domains.

HOW DOES AI WORK?

At its core, AI works like a smart assistant, learning from experience to handle tasks on its own. Imagine teaching a computer to recognize patterns and make decisions, much like we would train a pet. AI uses algorithms, which are like sets of instructions, to process information and learn from examples. Machine learning, a part of AI, allows the computer to improve over time without explicit programming. It's like the computer is learning from its mistakes and successes. Think of AI as having different skills, such as understanding language (NLP) or recognizing images (Computer Vision). These skills are honed through practice, much like how you get better at a game the more you play.

AI is not a physical machine but rather a set of smart abilities embedded in machines. Think of it like the brainpower inside your device. Enabling these devices to think and make decisions, almost like a digital brain. It is the intelligence behind the screen, enhancing the abilities of machines and making them more adaptable to various tasks.

ADVANTAGES

AI offers numerous advantages that enhance our daily lives. Firstly, AI makes tasks more efficient by automating repetitive and time-consuming processes. It can easily handle routine jobs such as data entry, accounting, and customer service, freeing up time for more mean-

Image Courtesy: Shutterstock

An image showing a surgeon wearing AR Headsets and using high-precision Remote Controlled Robot Arms to operate on a patient, while observing organs on Holographic VFX Displays

ingful activities. Secondly, AI excels at processing vast amounts of data quickly, leading to improved decision-making. For instance, in healthcare, AI can analyse medical data to assist doctors in diagnosing diseases more accurately and promptly. In the case of drug discovery, AI can identify potential hit compounds which can be developed into medicine (drug candidates) by screening libraries containing billions of molecules. Personalisation is another perk offering tailor-made recommendations based on individual preferences like suggesting movies, music, or shopping items, AI understands your likes and dislikes, providing a more personalised experience.

Ultimately, AI powers smart devices, making them more intuitive and making interactions with technology more user-friendly. In industries, AI optimises processes, reducing costs, increasing productivity, and enhancing safety.

DISADVANTAGES

While AI brings many benefits, there are potential drawbacks to consider. One concern is job displacement, as AI and automation could replace certain human tasks, impacting employment in some industries. Some of the jobs that might get replaced very shortly are graphic designers, accountants, financial analysts, market research analysts, legal assistants, content creators, technical writers, journalists, coders, computer programmers, software engineers, and data analysts. The list is very long, however, the rise of AI is creating many jobs too.

Another issue is bias in AI algorithms. If the data used to train AI systems is biased, the AI may perpetuate or even exacerbate existing social inequalities. For instance, biased algorithms in hiring processes might unintentionally favour certain demographics over others. Privacy is another significant concern, as AI often relies on large datasets, and mishandling this data could lead to privacy breaches. Moreover, there's the challenge of accountability as it's not always clear how AI-based decisions are reached. This lack of transparency raises questions about who is responsible if something goes wrong.

Lastly, there are ethical dilemmas, especially in areas like autonomous weapons, where AI can be misused. It's crucial to establish ethical guidelines to ensure responsible AI development and deployment. In essence, while AI offers remarkable advantages, addressing issues related to job displacement, bias, privacy, accountability, and ethics is crucial to ensuring its responsible and beneficial integration into our lives.

CHALLENGES

AI faces several challenges that impact its development and integration into society. One significant challenge is the need for vast amounts of data to train AI systems. Data is fuel for AI and without enough diverse and high-quality data, the systems may not perform well or could even perpetuate biases present in the data. Interpreting and understanding the decisions made by AI is another challenge. AI often operates as a 'black box', making it challenging to explain how it arrives at specific conclusions. This lack of transparency raises concerns about accountability and trust. Ethical concerns pose a significant challenge too. As AI becomes more advanced, questions arise about its responsible use, particularly in areas like privacy, security, and potential misuse of autonomous weapons. Ensuring fairness and preventing bias in AI algorithms is a continuing struggle. Moreover, there's the challenge of keeping pace with rapid advancements in AI technology. It requires ongoing efforts in education and regulation to ensure that the benefits of AI are realised without compromising ethical standards or widening societal divides. Addressing these challenges is crucial for the responsible and beneficial integration of AI into our daily lives.

If the data used to train AI systems is biased, the AI may perpetuate or even exacerbate existing social inequalities

RISKS ASSOCIATED WITH THE USE OF AI

The rise of AI brings along potential risks and fallouts, including the misuse of technology. Deepfake is a notable example, where AI is used to create convincing but entirely fabricated content, like videos or audio recordings, often for deceptive purposes. This raises concerns about misinformation and the manipulation of digital media. Voice cloning is another area where AI can be misused. Advanced voice synthesis algorithms can replicate someone's voice with remarkable accuracy, potentially leading to impersonation or fraudulent activities. Imagine someone using AI to create a fake voice recording that sounds exactly like a trusted individual. Additionally, there are concerns about AI-powered autonomous weapons, where machines make decisions about targets without direct human intervention. This raises ethical questions about the potential for misuse and the need for responsible development and deployment of such technologies.

Ensuring the ethical use of AI is crucial to mitigating these risks. Implementing regulations, educating the public, and developing ethical guidelines for AI development are essential steps to minimise the negative consequences and promote the responsible use of this powerful technology. As AI continues to advance, addressing these challenges becomes increasingly important for a secure and trustworthy digital future.

GLBOAL SCENARIO AND INDIA'S POSITION

AI is a rapidly evolving field with global significance. Many countries and industries are investing heavily in AI research, development, and applications. The global AI landscape involves advancements in machine learning, natural language processing, computer vision,

and robotics. Major players in the AI space include the United States, China, Europe, and several other countries with active AI research and implementation initiatives. India has been increasingly recognising the importance of AI and has taken steps to contribute to the global AI landscape. The country has a growing pool of AI researchers, professionals, and startups. The Indian government has shown interest in fostering AI development, with initiatives like the National Strategy for Artificial Intelligence to establish itself as a significant player in the global AI ecosystem.

Krutrim, a groundbreaking Indian-made AI, promises to revolutionise the digital landscape for millions. This large language model, which debuted as 'India's own AI", can understand and generate contents in 10 Indian languages, including Hindi, Bengali and Tamil. This focus on inclusivity aligns with its innovative architecture, boasting improved performance and efficiency. Krutrim has the potential to unlock diverse applications across sectors like education, customer service, and content creation. Bridging the digital divide and bringing the power of AI to millions who were previously left behind and catering to the unique needs and challenges of the Indian market. Krutrim is not just a technological marvel; it's a symbol of progress and inclusivity, offering a glimpse into a future where language is no longer a barrier to progress.

APPLICATIONS

AI has immense applications in almost every domain, some of which are:

1. Healthcare: AI assists in early disease detection, personalised treatment plans, and drug discovery. It can help analyse scans to spot tumors or robots performing intricate surgeries with enhanced precision.

2. Finance: Fraud detection is one of AI's superpowers. By analysing transactions and identifying patterns, AI guards against financial crime. Additionally, AI algorithms provide market insights and automate financial planning.

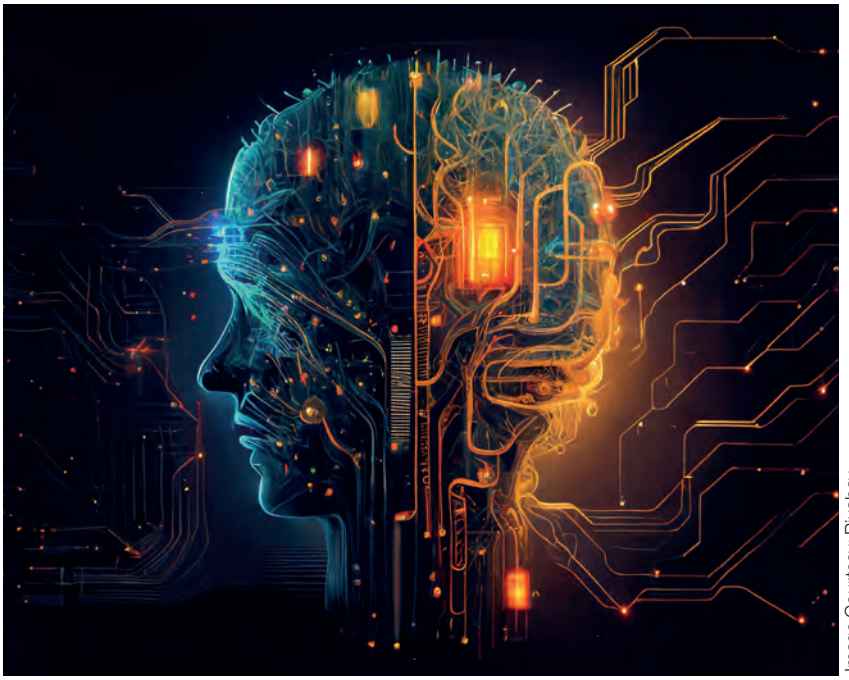

Image Courtesy: Pixabay

3. Retail: Personalised recommendations based on your browsing habits ensure you see products you'll love, while chatbots answer questions and complete purchases seamlessly.

4. Education: AI tutors offer personalised learning paths, adapting to each student's pace and needs. Imagine automated grading freeing up teachers for deeper, one-on-one interactions. Additionally, AI translates languages, making educational resources accessible to a wider audience.

5. Transportation: Self-driving cars are on the horizon, powered by AI algorithms that navigate roads and react to situations instantaneously. In public transportation, AI optimises routes and schedules, ensuring smoother commutes.

6. Environment: AI tackles environmental challenges from climate modeling to pollution monitoring, from predicting natural disasters to tracking endangered species.

7. Manufacturing: AI optimises production processes, predicting equipment failures and ensuring quality control. Imagine factories running like clockwork, with robots working alongside humans guided by AI.

8. Creativity: AI is even making its mark in creative fields, composing music, writing poetry, and generating stunning artwork. While not replacing human creativity, AI offers new tools and possibilities for artistic expression.

NEED OF REGULATORY MECHANISM FOR THE USE OF AI

The accelerating progress of AI has ignited a pressing need for regulatory frameworks to navigate the ethical, legal, and societal implications that accompany its widespread integration. With AI applications becoming increasingly influential, concerns regarding privacy, bias, and accountability have intensified. Ethical considerations in AI development, especially in areas such as healthcare, finance, and employment, highlight the necessity for guidelines that ensure responsible practices.

Moreover, the extensive use of large datasets in AI raises privacy concerns, prompting the call for regulations to delineate the appropriate collection, storage, and utilisation of data. Security is another critical aspect, with the potential for malicious uses of AI necessitating regulatory measures to safeguard against cyber threats. Establishing accountability and liability frameworks for AI-related incidents further underscore the importance of regulations. International collaboration is key, recognizing the global nature of AI, and efforts are underway in various regions to create standards that strike a balance between fostering innovation and protecting individuals and society.

**The writer is Assistant Professor, Department of Pharmaceutical Engineering & Technology, Indian Institute of Technology (BHU), Varanasi.*

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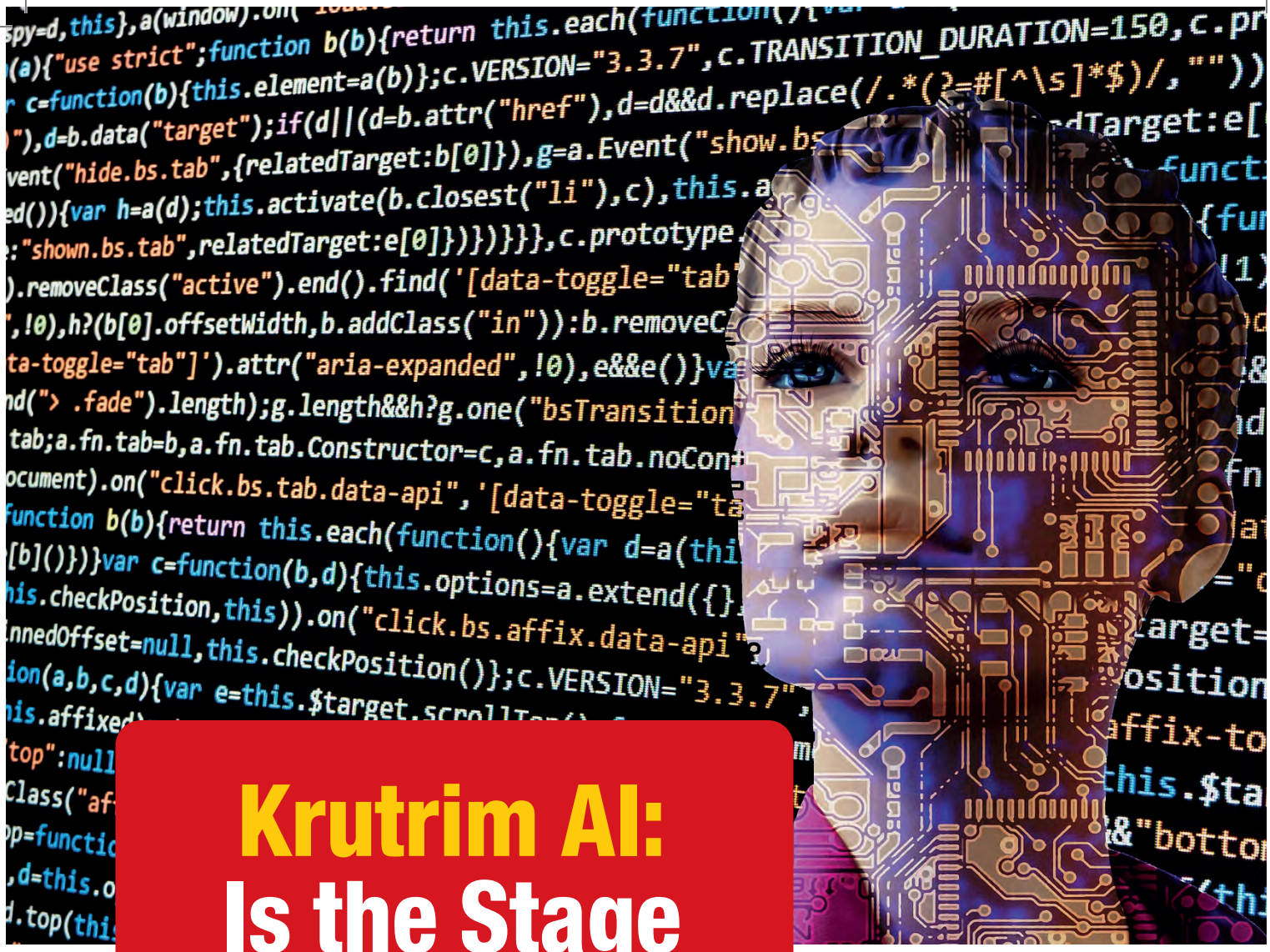


Krutrim AI: Is the Stage Finally Set for a Visionary India-specific Large Language Model?

Krutrim AI brings the world of Artificial Intelligence closer home, signalling a quantum leap that human civilisation is set to undertake

■ Richa Mishra and Prof Shandar Ahmad

As the curtains on a wonderful year of India's rapid progress in science and technology started fluttering to usher in a new year, the final month of 2023 saw the promise of a new era of Artificial Intelligence (AI) in India, unveiled by Ola-famed Bhavish Aggarwal on December 15. This came in the form of a breath-taking inauguration of Krutrim AI by Krutrim Si Designs. As has rapidly become common knowledge, Krutrim in Sanskrit means 'artificial' and the thoughtful adoption of the term deliberately signifies the nationalist perspective of AI.

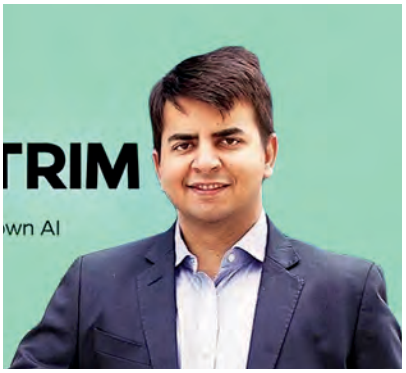
Almost exactly a year ago, the world had woken up to the revolution created by an AI-based service ChatGPT launched by OpenAI. ChatGPT is a popular tool, enabled by a powerful AI technology called Large Language Models (LLMs). Here, we take a look at the LLM techniques and what it means to have an India-specific model of AI that Krutrim promises.

LARGE LANGUAGE MODELS (LLMs)

Data-driven machine learning models can not only generate missing components of sequential data such as spoken language but also provide inputs just like any intelligent individual in almost any field of knowledge. These models are also trained on real data and their ability to generate content depends on the data used during training. LLMs are trained on huge amounts of natural language information taken from the internet, proprietary content, books, or any source of information that these models can lay their hands on. Due to the complex nature of human natural language, a representation of human spoken words is created in an encoded space and the training is performed on these representations, called tokens. For a quick understanding, each word or each unit of meaningful information used for training LLMs can be thought of as a token. These tokens are processed in an LLM through computational models with a number of Parameters, which come into action in the application stage of these models. The process of training is essentially finding these parameter values which can best describe the knowledge contained in the training data. The number of tokens used during training, together with the size and quality of training parameters are important indicators of the power of specific implementations of LLMs.

DO LLMs HAVE A NATIONALITY?

A trained LLM can only understand the tokens that have been used during training, although novel patterns can be generated using different sequences of occurrences of these tokens. If a particular vocabulary was not represented



KRUTRIM, developed by Krutrim Si Designs, spearheaded by Ola CEO Bhavish Aggarwal, stands tall as India's own AI model

at the tokenization of training data, the LLMs will be unable to generate a text in that vocabulary. Moreover, since the LLMs are based on training, the contents they generate are essentially a representation of the data used in their training. Thus, the LLMs carry not only the syntactic scope of the language used for its tokenization but also the values, the logic, and the substance of the contents on which they were trained.

LANGUAGE CAPABILITIES OF LLMs

At the time of writing this article, ChatGPT claims to understand more than 75 international languages, including 15 Indian languages. Google's Bard also understands more than 40 languages including some Indian ones. One has to understand the difference between the languages that an LLM is capable of communicating in and the languages in which the models were originally trained. This is because an LLM-based engine can easily be integrated with language translation systems, an area in which several of these enterprises already have a huge presence. The exact data on which an LLM was trained by an enterprise is usually not known. Some insights into the size and broad categories of the data used for training are provided in their technical notes but that is insufficient to know what went behind the product we use.

LOCALISATION BEYOND LANGUAGE

AI-based systems attempt to mimic the human brain but go beyond the brain's capacity by packing up huge amounts of data into a computer model. Yet, the models remain qualitatively similar to the brain's functioning. In some sense, an AI model can be thought of as an intelligent human with a huge amount of memory and the most efficient human intelligence to answer questions. Similar to the power of solving problems, machines also inherit the cultural sensibilities and values of the data, just as a human being acquires values under the supervision of his elders or personal experience (data). Since every intelligent man is different, so will be the machines that mimic them. It is in this context that a nationalist version of AI-based LLM can contribute. Krutrim therefore is expected to be an intelligent machine that inherently understands the beliefs, sensibilities, and cultural notions of Indian society.

ISSUES OF SECURITY AND SOVEREIGNTY

Computer technology has moved rapidly over the past decades into the areas that require sharing your data to make its best use. For example, asking questions in the Google search engine, using open access coding platforms and millions of online services for various tasks is possible only when we upload our data to the internet services. While this poses no threat in a world that runs on principles and mutually respected rules, there remains a risk that the uploaded data may be compromised by the service provider, hackers, or even the future foreign governments under which these services are operated. Powerful technologies will be missed out where sensitive data needs to be processed through these vulnerable channels and therefore a national resource in AI/LLM models is very much needed.

IMPLICATIONS TO MARKETING AND PRODUCT RECOMMENDATIONS

More and more users are engaged with LLM-based services and often ask simple questions when deciding to buy products. National resources to engage a wider customer base is likely to be at the heart of future marketing and an India-specific service is essential to protect

World of Language Models: A Global Comparison

	ChatGPT (USA)	Bard (USA)	AI21 studio (Israel)	Wu Dao (China)	KoGPT (Korea)	YaLM 100B (Russia)	Krutrim (India)
Developed/ owned by	OpenAI	Google	AI21 labs	Beijing Academy of Artificial Intelligence (BAAI)	Kakao Brain	Yandex	**Krutrim Si Designs**
Founded/ started development in	2015	2015	2017	2020	2017	2022	**2023**
Headquarters	San Francisco	California	Tel Aviv	Beijing	Jeju City	Moscow	**Bengaluru**
Languages understood	More than 75 languages including 15 Indian languages as claimed by AskAI	46 international languages	English, and some European languages	Chinese and English	Korean	Russian, English	**English, most of the 22 official Indian languages**
Data source	~45 terabytes of text from the Internet	InfiniSet (C4 dataset and Wikipedia)	Web-scraped text, books, articles, dialogue scripts, and creative text formats	1.2TB Chinese text data in Wu Dao Corpora, 2.5TB Chinese graphic data and 1.2TB English text data in the Pile dataset	COYO-700M: Image-Text Pair Dataset	1.7 TB of online texts, books, and datasets including Pile, Taiga, Russian Distributional Thesaurus, and Yandex Search index	**~2 trillion tokens collected from Indian sources**
Number of model parameters	175 billion	137 billion	178 billion	1.7 trillion	6.2 billion	100 billion	**1.5 billion**
Approx. no. of tokens/ vocabulary size during training	13 Trillion tokens	Undisclosed	Undisclosed	1.2 TB of text data	200 Billion tokens	300 Billion tokens	**2 Trillion tokens**

Indian businesses and customer choices.

ISSUES OF TECHNOLOGY FOR FURTHER DEVELOPMENT

LLMs not only provide answers to obvious questions, write computer programs, and create poetry and paintings, but are expected to be used in solving serious scientific and technological problems and will form the backbone of future research and development. Many scientific problems are already using the power of LLMs and over-reliance on a limited number of service providers is risky.

KRUTRIM: WHAT DOES IT TRY TO ACHIEVE?

Krutrim aims to bring home the technology that is revolutionizing almost every human activity and in the language that the home understands. Krutrim is not the first India-specific initiative, as several exciting projects in this area are underway, and have been covered by other sources (see for example, https://www.analyticsvidhya.com/blog/2023/12/llms-that-are-built-in-india/). However, the size and scope of Krutrim and the pace at which it has seen the light of the day appear to be amazing. Krutrim aims to provide an India-specific service much the same way as Wu Dao does for Chinese for example, but goes much beyond that. Particularly the diverse nature of Indian languages and cultural and social ethos of India require a larger selection of training data and a deeper level of training and coverage of contents. Bhavish Aggarwal an Indian entrepreneur and the co-founder of Ola Cabs, started this ambitious project only in 2023 and has quickly seen the light of the day. The product will be available for larger public scrutiny and use this month and it is with great curiosity and expectation that we await KrutrimAI, India's great leap into the world of LLMs.

**Richa Mishra holds a master's in Medicinal Chemistry and Drug Design, and is currently working as a project associate at SciWhyLab, SCIS, JNU. Prof Shandar Ahmad specialises in the field of Bioinformatics and Data Science. He is a former Dean and currently a Professor at School of Computational and Integrative Sciences (SCIS), JNU, where he also leads the research lab called the SciWhyLab. He can be contacted at shandar@jnu.ac.in*

COVER STORY

Unlocking the Potential of AI in Agriculture

With two-thirds of Indian population still dependent on agriculture, and the sector accounting for 19% of GDP, technological disruptions such as AI can bring about path-breaking changes in Indian agriculture, making it more efficient, sustainable and inclusive

■ **Ambica Vankamamidi and Raj Seelam**

Image Courtesy: Shutterstock

Artificial Intelligence can drive the next agricultural revolution in India to achieve the much-required leap in productivity and food security. India witnessed mission mode-driven changes through Green Revolution, White Revolution, Yellow Revolution, Blue Revolution, and Purple Revolution (Aroma Mission). Artificial Intelligence (AI) in Indian agriculture can catalyse innovation to bring holistic changes, making it more efficient, sustainable and inclusive.

What is AI? AI is the science of making machines think like humans. A subset of AI is machine learning (ML), which refers to the concept that computer programs can automatically learn from and adapt to new data without being assisted by humans. ML provides rich recommendations that benefit farmers.

STUMBLING BLOCKS

According to the Economic Survey 2022-23, the agriculture sector is witnessing an average annual growth rate of 4.6 per cent over the last six years. Dependence on monsoons, small and fragmented land holdings, lack of equipment, access to quality seed and technical advice to improve crop yields, risk of crop damage due to pests, limited

mechanisation, absence of agricultural marketing facilities, and lack of access to traditional finance are barriers to wholesome development.

Farmers often pay inflated interest more than market rates on the capital they borrow. Extensive use of fertilisers and pesticides resulted in pest resistance and deteriorating health of farmers, soil and environment. Technology infusion can unlock the growth potential of the agricultural sector.

TECHNOLOGY INITIATIVES

National Agriculture Market (eNAM), India Digital Ecosystem of Agriculture (IDEA), National Mission for Sustainable Agriculture (NMSA), National e-Governance Plan in Agriculture (NeGPA) are reform initiatives to boost farm revenue.

The Ministry of Agriculture and Farmer Welfare initiated Agri Stack, a digital foundation, to bring various stakeholders in agriculture on one platform for better outcomes. With a new focus on Farming as a Service (FaaS), targets for AI-led innovations have been identified to increase income, farm productivity and waste reduction. Application of AI, ML, IoT and blockchain are useful in crop and soil health monitoring, predictive analytics and supply chain efficiencies.

SOIL HEALTH

In India, soil health is affected by varying degrees of degradation due to the overuse of chemical fertilisers, poor irrigation and farm management techniques. Machine learning can aid farmers in getting a quick analysis of their soils much earlier than laboratory reports.

Data from soil reports, temperature, weather, humidity, and historic crop performance provide insights into various practices like the right time to sow seeds or harvest the crop. The use of drones empowers farmers to enhance productivity, reduce costs, and improve environmental sustainability. Equipped with multi-sensor cameras, drones facilitate inspection for pests and water requirements.

With a new focus on Farming as a Service (FaaS), targets for AI-led innovations have been identified

Real-time data and advice on improving soil quality allow farmers to take immediate measures. In a few tech applications, farmers upload pictures of their soils or pest infested crops to get immediate information on remedial actions.

The Namo Drone Didi program will provide drones to 15,000 selected women Self Help Groups (SHGs) for providing rental services to farmers. The scheme seeks to empower women SHGs while ushering in new technologies through drone services.

The Soil Organic Carbon (SOC) improves soil aeration, water retention capacity, and drainage and enhances microbial growth. Sustainable farming practices supported with AI solutions and remote sensing data improve SOC. Carbon credits earned from these sustainable practices can be traded under the Carbon Trading Credit Scheme.

FARMER CENTRIC

Farmers are the heart of various agri-tech initiatives. Right from inputs such as seeds, agrochemicals, advisories and finance are focused on farmers. The change towards a farmer-centric approach, away from *mandi*s, can potentially turn agriculture profitable and boost its contribution to India's economy.

AI-powered systems can create a sustainable environment for protecting the health of farmers. A real-time insight into soil conditions, moisture levels, and crop health aids in the optimal use of fertilizers and pesticides, thereby protecting farmers from over exposure to chemicals on farms.

Analysis of demand and supply chain bottlenecks in real-time offers suggestions to cultivate according to the projections of demand and supply, bringing transparency in crop prices and their by-products, and helping farmers earn more income. AI-powered apps improve quality and ensure faster market access for the produce, reducing wastage.

The PM-Kisan App designed by the National Informatics Centre and the Ministry of Electronics and Information Technology supplements the financial needs of land-holding farmers. Through the Viksit Bharat Sankalp Yatra, more than 34 lakh farmers are added back to the list of beneficiaries of the PM Kisan Samman Nidhi Yojana (PM-Kisan).

WATER & ENERGY CONSERVATION

Water makes up over 70% of the earth's surface area, and the total amount of freshwater only makes up around 3% of the water supply, making it a precious resource. Optimising the use of inputs is the main objective of precision agriculture. Low-cost sensors and data analyt-

ics help in waste reduction and minimise greenhouse gas (GHG) emissions.

Improved soil health enhances the water and nutrient-holding capacity of the soil. Targeted AI interventions prevent overwatering in farms. Energy consumption patterns are analysed to recommend plans to minimise wastage. AI tools aid climate control systems in greenhouses and provide round-the-clock monitoring for horticultural practices. Conservation agriculture improves yields, saves water and energy and improves carbon sequestration.

DIGITAL ECOSYSTEM

Investment opportunities and innovative solutions are aplenty, making agriculture an attractive domain for startups. More than 1,000 startups have mushroomed throughout the country. A major step in creating a digital ecosystem is rising internet penetration in rural India. Apps, innovations, agrifintechs and large technology companies are working to ramp up the value chain through digital technologies. More than 30 million Indian farmers possess smartphones. They can access AI recommendations to make informed decisions that enhance their productivity and income. The young are more open to technology disruptions in agriculture than the older generation farmers who believe in a wait-and-watch policy.

Image classification tools combined with remote and local sensed data can bring a revolutionary change in the utilisation and efficiency of farm machinery in areas of weed removal, harvesting and grading. A few AI innovations include AI-based chatbots to provide farmers with customized notifications and short videos on a real-time basis, helping them plan and manage crops efficiently.

Microsoft in collaboration with ICRISAT developed an AI sowing app that provides sowing advisories to participating farmers. The advisories contain essential information such as optimal sowing date, soil test-based fertilizer application, farm yard manure application, seed treatment, optimum sowing depth, and more.

Technology informs farmers to reduce the use of herbicides by spraying only where weeds are present. Predictive analytics gives accurate supply and demand information, thus reducing information asymmetry between farmers and intermediaries. NITI Aayog and IBM have partnered to develop a crop yield prediction model using AI to provide real-time advisory to farmers. The project is under implementation in Assam, Bihar, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh.

PUBLIC PRIVATE PARTNERSHIPS

The Artificial Intelligence for Agriculture Innovation (AI4AI) of the World Economic Forum (WEC) promotes AI and other technologies in Indian farms. Currently, the AI4AI aims to leverage Public Private Partnerships for scaled and responsible deployment of agritech innovations.

More than 30 million Indian farmers possess smartphones. They can access AI recommendations to make informed decisions that enhance their productivity and income

In Maharashtra, the Mahila Arthik Vikas Mahamandal in collaboration with AI4AI is initiating to work with 1.8 million women across the state. Women farmers will have access to advisory and inputs shared through multiple channels to improve yield and optimise the use of resources, and tech-enabled platforms to improve market access, leading to higher returns and reduced post-harvest losses.

In Uttar Pradesh, WEC and the Digital Agriculture and Export Promotion (DAEP) Council are working towards leveraging technology for supply chain efficiency and building digital public infrastructure for agriculture in the state.

In Telangana, WEC partnered with the state government to launch the Saagu-Baagu. More than 7000 chili farmers are engaged in this programme. They receive support in quality testing, soil testing, crop health monitoring, window prediction, tillage estimation and accessing new customers and suppliers.

LIMITATIONS

Fragmented technological infrastructure, high cost of operations, lack of access to data and limited technical expertise hamper the scale of these technologies. There is a requirement to have disaggregated data to find solutions for a location-specific problem.

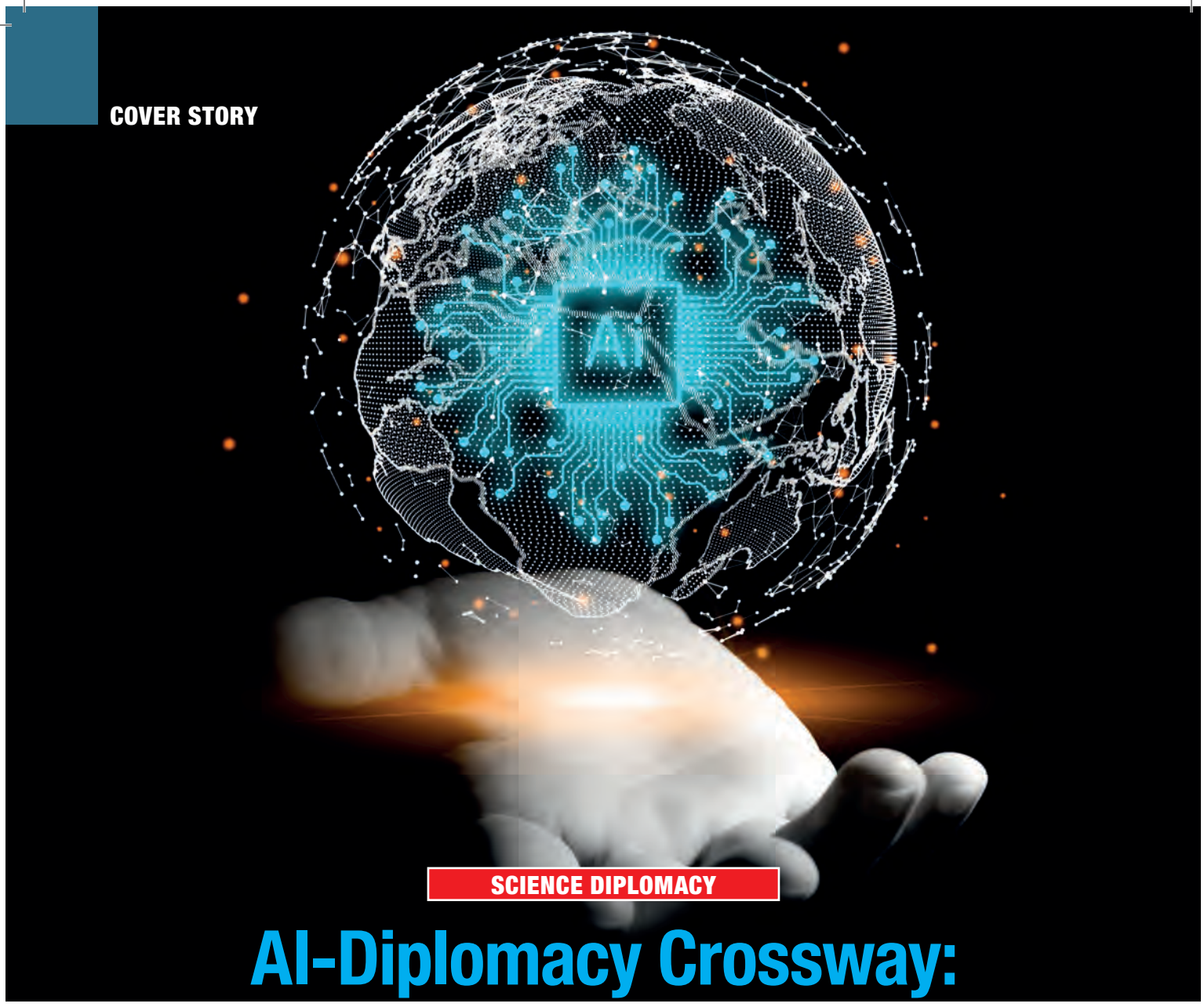
AI is capital-intensive. It can be difficult to convince farmers to pay for advisory services. Therefore, startups focus on areas where there is revenue visibility. Big players offer personalised advisories bundled with the sale of farm inputs such as seeds.

Outreach programmes create awareness of the use of AI-enabled technologies. Pilot projects suitable to specific areas and crops throughout the country help farmers understand the potential of AI.

The farmers can be incentivised to use low-cost IoT kits that are required to gather real-time data. R&D, incubators and startups require promotion. Sustained investment in data infrastructure to catalyse research, innovation and application is essential. Importantly, laws that respect privacy and provide safeguards for personal data protection and collective rights of farming communities to their data are required to create trust in farmers that their data is safe.

Agritech is gaining momentum, as many new players are eager to join the ecosystem. Creating sustainable livelihoods and promoting traditional practices are crucial for the success of any technological disruptions in Indian agriculture.

**Ambica Vankamamidi is Senior Manager, Head of Corporate Communications, 24 Mantra Organic, and a science communicator, while Raj Seelam is founder and MD of Sresta Natural Bioproducts Limited .*



SCIENCE DIPLOMACY

AI-Diplomacy Crossway: India's Vision for Responsible and Ethical Global Leadership

With AI consuming our lives extraordinarily and the world grappling with its potential and pitfalls, India emerges as a pivotal figure for ethical AI-driven diplomacy

■ Uday Kumar Varma

Few debates in intensity and seriousness consume the world's mind and attention today as the discussion on the positive and deleterious, the creative and destructive aspects of Artificial Intelligence (AI). The recent reports of virtual crimes on Metaverse, while deeply disturbing, pose an unprecedented challenge. It can be said without much reservation that the world is set on a future course that will not only be aided and guided by AI but will certainly be dominated and possibly controlled by it. There is a real palpable danger of humans being enslaved by their own creation.

The advent of Artificial Intelligence (AI) marks a transformative phase in the evolution of global dynamics, not only reshaping economies but also redefining the principles of diplomacy. As the world grapples with the potentials and pitfalls

Image Courtesy: Shutterstock

of AI, India emerges as a pivotal player, showcasing exceptional leadership and a vision for responsible and ethical AI-driven diplomacy. This article delves into the emerging importance of AI, its economic implications, and India's role in shaping a future where technology is harnessed for the benefit of humanity.

ECONOMIC IMPLICATION OF RISING AI

While AI is not only disruptively transforming the world order, its economic implications are evidently staggering. In 2022, the global AI market size was valued at $136.55 billion and is expected to rise exponentially in the coming years, supported by increasing AI investments, digital disruption, and competitive advantages in this rapidly growing economy. The global AI market size is expected to increase at a CAGR of 37.3% from 2023 to 2030 and will be in the vicinity of a monumental $1,811.8 billion by then. It is expected to contribute $15.7 trillion to the world economy, more than India and China's current combined output. China is anticipated to experience a 26% rise in GDP, with North America closely following, accounting for almost 70% of the global economic impact.

The surge in AI adoption globally is overwhelming, as enterprise AI adoption rates have doubled since 2017. Notably, Indian and Chinese companies are leading the charge in AI implementation. The impact on the workforce is profound, with McKinsey estimating that up to 15% of the global workforce, nearly 400 million workers, may face displacement by 2030. However, AI is also poised to increase labour productivity by up to 40% across various sectors by 2035, presenting a complex but transformative landscape.

AI, a force that promises both creative innovation and potential destruction, is undeniably becoming the cornerstone of global progress. Where does India stand in this emerging economic configuration?

INDIA'S EMBRACE OF AI

India, with its fast-digitizing sectors like healthcare, finance, automotive, and telecommunications, is swiftly embracing AI.The future projections are not only upbeat, but they also likely ensure a leadership position for India in next 5-10 years. The AI market size reached $ 680 million in 2022 and is expected to reach $3,935.5 million by 2028, with a CAGR of 33.28% between 2023 and 2028. AI expenditure in India increased by 109.6% in 2018 and is expected to grow at a CAGR of 39% to hit $11,781 million by 2025. AI can add nearly $500 billion to India's GDP by 2025.

India is a major player in AI talent and ideas and the Indian youth are actively contributing to AI advancement, aiming to bring about social change through technology. The government is committed to AI for all, drafting policies and programs to leverage AI for social development and inclusive growth. Initiatives include the National Program on Artificial Intelligence and the soon-to-be-launched AI Mission.

Frontally led by the vision and resolve of Prime Minister Narendra Modi's leadership, this embrace, emphasizing responsible and ethical AI development, seems certain to catapult India in the forefront of a global transformation riding on the positive and creative application of AI.

GPAI SUMMIT AND INDIA'S LEADERSHIP

The recently held Global Partnership on Artificial Intelligence (GPAI) Summit in New Delhi showcased India's exceptional leadership. As the lead chair of GPAI in 2024, India has positioned itself at the forefront of AI diplomacy. Prime Minister Modi emphasised responsible and ethical AI development, while harnessing its full potential for faster and inclusive growth.

AI AS A DIPLOMATIC TOOL

AI is rapidly transforming the contours and content of modern diplomacy. Gone are the days of conjectures and intelligent anticipation; AI can enable nations to discover facts and fathom with certainty, what once were the imponderables. Diplomacy is never going to be the same now.

The ability of AI to process vast amounts of data, engage in predictive analytics, facilitate language translation, and contribute to cybersecurity positions it as an invaluable asset for nations in the international arena.

Ways AI can contribute to diplomacy include:

1. **Data Analysis and Decision-Making:** AI can process large datasets, providing comprehensive insights for informed decision-making.
2. **Predictive Analytics:** Forecasting geopolitical developments and economic trends to formulate proactive diplomatic strategies.
3. **Language Translation and Communication:** Overcoming language barriers for effective communication in international negotiations.
4. **Cybersecurity and Information Warfare:** Enhancing cybersecurity efforts and countering disinformation campaigns in the digital realm.
5. **Climate Change and Environmental Monitoring:** Leveraging AI to address global challenges such as climate change through data analysis.
6. **Autonomous Vehicles in Diplomacy:** Utilizing autonomous vehicles, including drones, for diplomatic missions and disaster response.
7. **Crisis Response and Humanitarian Aid:** Coordinating responses to emergencies using AI-driven systems for optimal outcomes.
8. **Trade and Economic Diplomacy:** Analysing economic data to provide insights for diplomatic efforts in trade negotiations.
9. **Simulations and Scenario Planning:** Using AI-powered simulations for strategic planning and risk assessment in international relations.
10. **Cross-Cultural Understanding:** Incorporating AI's analysis of cultural nuances into diplomatic strategies to foster positive relationships.

CHALLENGES AND ETHICAL CONSIDERATIONS

And yet, AI like all marvels of nature and transformative human innovations, has a distinctly dual nature capable of both significant development and deadly

Image Courtesy: PIB

Prime Minister Narendra Modi inaugurated the Global Partnership on Artificial Intelligence Summit 2023 at Bharat Mandapam, New Delhi, last month

destruction. While it presents numerous opportunities for diplomatic innovation, it also raises ethical and security concerns. Privacy, accountability, and potential misuse of AI must be carefully considered to balance technological advancements with ethical considerations.

The 'deepfake' challenge, cybersecurity threats, data theft, and the potential misuse of AI by terrorist organizations highlight the misuses that can overwhelm humanity. The gravest indictment of AI's pernicious side comes from none other than Sam Altman himself, the creator of ChatGPT. "My worst fears are that (the AI industry) will cause significant harm to the world," he said. "If this technology goes wrong, it can go quite wrong." Such evaluation is shared by many other giants in the field of AI including the irrepressible Elon Musk.

Almost four years ago, even when AI's scope was yet to find the modern contours, an unusual initiative was undertaken, not by the humanists or the politicians or intellectuals, but by Pope Francis. The Vatican hosted a dialogue in Rome where AI industry leaders and catholic priests came together to deliberate over the concerns arising out of AI's applications. The upshot of this deliberation was 'Rome Call for AI Ethics' — a six-point charter that sought to promote an ethical approach to artificial intelligence", making an appeal to "Grant centrality to man". The dialogue coined a new word "algorethics" — ethical algorithms.

Another initiative, the Bletchley Declaration of which India is a part, exemplifies the idea of international diplomacy, where countries join under the same roof to address our time's most intricate and transformative technological advancements.

PM Modi has taken the lead in adding urgency to it, saying, "Bharat calls upon the entire world that we should not waste even one moment. We have to complete the global framework within a given time limit. This task is very important to protect humanity".

A philosophical and moral framework must accompany such epoch-making technological advancement. It needs guidance, sensibility and sanity. India may as well become the torch bearer in this exciting and unique forthcoming journey of humankind.

INDIA'S COMMITMENT TO RESPONSIBLE AI

India's calls for Responsible Human-Centric AI governance emphasises the importance of ethical considerations. The G20 New Delhi Declaration reaffirms the commitment to 'AI Principles', stressing the need for a global framework to prevent the misuse of AI. The urgency expressed by Prime Minister Modi in creating a global framework for ethical AI resonates with India's diplomatic principles. The Rome Call for AI Ethics and the Delhi Declaration emphasise the collaborative efforts required to ensure the responsible use of AI on a global scale. The impending Meta era must be tempered by strong and resolute ethical interventions.

INDIA'S ROLE AND FUTURE LEADERSHIP

India's embrace of AI, coupled with a commitment to responsible and ethical use, positions it as a future global leader. The country's ancient traditions and cultural values contribute to a diplomatic approach that seeks equity, reason, and global collaboration.

"There are only two forces in the world, the sword and the spirit. In the long run, the sword will always be conquered by the spirit," said Napoleon Bonaparte. He perhaps did not believe in what he said as events in his life proved, but he did provide an invaluable guiding principle to modern diplomacy.

AI is essentially a spirit as it transforms the world and diplomacy, India stands at the forefront, championing responsible and ethical AI. Her leadership of GPAI raises many expectations and the world awaits remarkable initiatives to ensure that AI becomes an instrument of global good and not a pernicious tool of destruction and depredation.

India today enjoys a rare respect and credibility in international affairs. With Prime Minister Modi's vision of 'One World: One Future', India's AI-aided diplomacy is poised to determine the trajectory of global relations in the 21st century.

**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.*

WOSC

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Theme

Sustainable Utilization of Ocean in Blue Economy

Sub Themes

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EXCLUSIVE INTERVIEW: DR JITENDRA SINGH

Indian Science to Push the Envelope from Himalayas to Deep Ocean

The minister dispels the notion that startups can be created only by super qualified individuals, and points at success stories many of which are helmed by those not even graduates

■ **Debobrat Ghose**

Image Courtesy: PIB

In the past few years, India's achievements in various fields of science have dominated headlines the world over, forcing the traditional leaders of modern science to pause and applause. Leading the scientific community of the country in its various ambitious programmes — from homegrown vaccine against corona virus to landing on the south pole of the moon and everything in between — is a man of science himself, **Dr Jitendra Singh,** as Union Minister of State (independent charge) for Science & Technology, among other portfolios such as Prime Minister's Office; Personnel, Public Grievances and Pensions; Department of Atomic Energy and Department of Space. However, he feels that one needn't be a science graduate to cultivate scientific temper and do something worthwhile with it for the society. He speaks on multifarious topics related to science and its implementation for India's growth in this exclusive interview with *Science India* while launching the magazine's web portal in New Delhi recently. Excerpts.

Could you talk about some landmark achievements of the Narendra Modi government in its nine-year tenure?

In these nine years, there have been several achievements in various domains of science and technology — from space to vaccine. There are success stories that have placed India on the global stage as a first line nation, where India has excelled and proved itself of the capacity which is now emulated by others. It has also exploded many of the myths about our incapability, with missions such as Chandrayaan-3. Today, we are the first to land on the South Pole of the Moon. We have gone beyond the West. For this, the credit goes to Prime Minister Narendra Modi and his government. Huge private investments are taking place.

Biotechnology is another success story. Vaccine is a big example. India was never taken seriously, even socially, for its healthcare concerns. In our country, people usually don't take medicine immediately after falling ill. They wait for some days for it to get cured by itself. It is this country that made its first

COVID vaccine and supplied it to other countries. So, the country, which was very poorly thought of as a therapeutic healthcare, is now becoming a leader in protective healthcare. This has led to a change in perception in favour of India.

Clean energy and climate is another area. Today, we are setting target net zero by 2070. Take the example of CSIR's Aroma Mission — so far, the entire startup was seen through the prism of Information Technology (IT). But we are an agro-based economy and that is our strength. We have proved that there can be startups in agriculture sector too.

There used to be a perception that startups could be created only by IIT and IIM graduates or after doing PhD. We changed this and in three years, we created 3,000 startups, out of which a large number of people are not even graduates. We have prepared a strategy like linking their products with the market, so that they can earn a decent livelihood out of it. These success stories have put India on a different pedestal and changed the world's thinking towards us.

This year, our astronaut is going on a mission to the International Space Station, where NASA will train the astronaut. They asked us for it. It speaks about India's potential and capability.

On many platforms, you have said that science is not just about those who are doing master's or research in science stream, but it's about temperament. A large number of students who couldn't pursue science or mathematics in academics, consider themselves inferior. How do you see this?

See, in our space sector there is no IITian. One who is educated in science has an advantage, but that doesn't mean who has not studied science doesn't have scientific temper. All we need is passion, creativity, innovation, commitment and scientific temper, and this makes one a good learner. Many startups in agriculture are by those who never studied Math, but that doesn't mean they are unscientific. There is no dearth of talent among our children.

Images Courtesy: Twitter

Clean energy sector (above) and India's agro-economy, with a focus on cultivation of lavender as part of CSIR's Aroma Mission (left), are two areas with great opportunities for startups

The Cabinet has approved transformative 'PRITHvi Vigyan (PRITHVI)' scheme, which has been mentioned as an overarching scheme. How is it going to benefit the country?

The major objectives of this scheme are augmentation and sustenance of long-term observations of the atmosphere, ocean, geosphere, cryosphere and solid earth to record vital signs of the Earth System; development of modelling systems for understanding and predicting weather, ocean and climate hazards and understanding the science of climate change, among others. The Ministry of Earth Sciences is mandated to translate 'Science to Services for the Society' in providing services for weather, climate, ocean and coastal state, hydrology, seismology, and natural hazards; to explore and harness marine living and non-living resources in a sustainable manner for the country and to explore the three poles of the Earth (Arctic, Antarctic and the Himalayas).

Can S&T play a major role in diplomacy and establishing bilateral relations?

Of course, it gives India a position of strength to relate to other countries. Sir CV Raman said that for a nation to progress we need science, more science and still more science. He said so many decades ago. This was his thinking, and he got the Nobel Prize. Today we are realising the wisdom of his words. There is no growth without science. The world has accepted this fact. Innovation is must and a common Indian thinks how he or she can find a solution to a problem from a small thing. Even if a person is illiterate but thinks about finding a solution for their livelihood, they have scientific temper. Maybe they are unaware of scientific principles, but have the temperament to find solutions.

Almost all state governments have been lacking in support of R&D. If state economies are to grow, states must invest in R&D. Are the states interested in a dialogue with the Centre on this matter?

They will do as per their needs. But in this direction, National Research Foundation (NRF) is a giant step. The

research going on in the state universities, state research institutes, etc., will be involved. 60-70% resources will be non-governmental. The demarcation between the public and private should also end.

For example, Himachal Pradesh has done a lot of work on Hing (asafoetida) [a few years ago, the state pioneered the cultivation of asafoetida plants; India does not grow this spice and is totally dependent on imports]. The states will get proactive once they get profit out of their ventures like Himachal Pradesh.

India's R&D footprint needs to grow. There is a need for private research laboratories in the LLP (limited liability partnership) format over and above the existing national institutions and universities. Is the National Research Foundation going to support such independent contributors to the nation?

Here, NRF will decide on how collaborations will take place, what will be the subject, etc. Earlier, public and private entities used to have apprehensions against each other… shaq ke nazar se dekhte the… The government used to see private players as thieves and private sector used to think of government as corrupt. Now, this culture or perception is ending. That kind of corruption is also not possible in the current regime. All need to work together.

Image Courtesy: Sonam Singh Subhedar

Dr Jitendra Singh signing a copy of *Science India* magazine during the launch of its web portal recently in New Delhi

How do you see the India International Science Festival (IISF), whose ninth edition will be held from 17-20 January in Faridabad?

IISF is playing a big role in popularisation of science. It is not a research conference but a festival. It caters to all sections of the society. The main objective is to promote science among common people. That's why we have involved children, students in large numbers. Academics is a part of it and IISF is not purely an academic conference. There is a strong need for science communication and dissemination of our scientific knowledge and heritage.

What are the big ticket projects and fundamental reforms that the government is planning to bring in its next term, as the people of this country expect 'Dil Maange More' from the Modi government?

(Laughs) … India's ranking in economy will reach the fourth position from the fifth. The space sector has opened up in a big way. In 2014, India's bioeconomy stood at just about $10bn and today it has touched $137 bn. We look forward to having $300 bn by 2030. India has made rapid strides in the last eight years. We have unique bioresources in the Himalayas. Future growth will come from here and Aroma Mission is all about that. It's our future.

Biotechnology will be the key to Amrit Kaal economy and also for making India a frontline nation in the world. The world is looking up to India as an emerging biomanufacturing hub.

Then, there is the 7,500 km-long coastline and under the Deep Ocean Mission, we are going to dig the unexplored biodiversity beneath the seas. It's going to be a big thing. In 2025, we will see one person (astronaut) going to the Low Earth Orbit on Gaganyaan, while the other will dive 6000 m deep into the ocean. That's going to be a big achievement of India that the world will witness.

**The interviewer is Editor, Science India.*

Chandrayaan-3 landed near the south pole of the Moon on August 23, 2023

All Images Courtesy: ISRO

VIEWPOINT

'Tis the Year When Vijnana Will Amalgamate With Adhyatma

India is a fast-growing economy of a resurgent civilisation that will excavate and prop up our ancient knowledge system and scientific wisdom

■ Prof (Dr) Chaitanya Giri

The Year 2024 is a big year for Bharat as a republic (Ganarajya) and as a civilization (Sanskriti). It is a year with two Deepavalis. At a time when we celebrate the return of the brightest star of the Suryavanshi clan, Shri Ram to his birthplace in Ayodhya, after an enforced exile of his *murti* (idol of Ram Lalla) for 500 years, Bharat's accolade-winning Aditya-L1 space mission is peering into the layers of the Sun from the Lagrangian point. 2024 is a year when science (*vijnana*) will not just meet, but amalgamate with spirituality (*adhyatma*). While the West will continue to silo *vijnana* and *adhyatma*, keeping the latter as a lesser of the two, Bharat's standing in global science pursuit will be that of an amalgamator.

ECONOMIC GROWTH: AN INWARD EXPLORATION

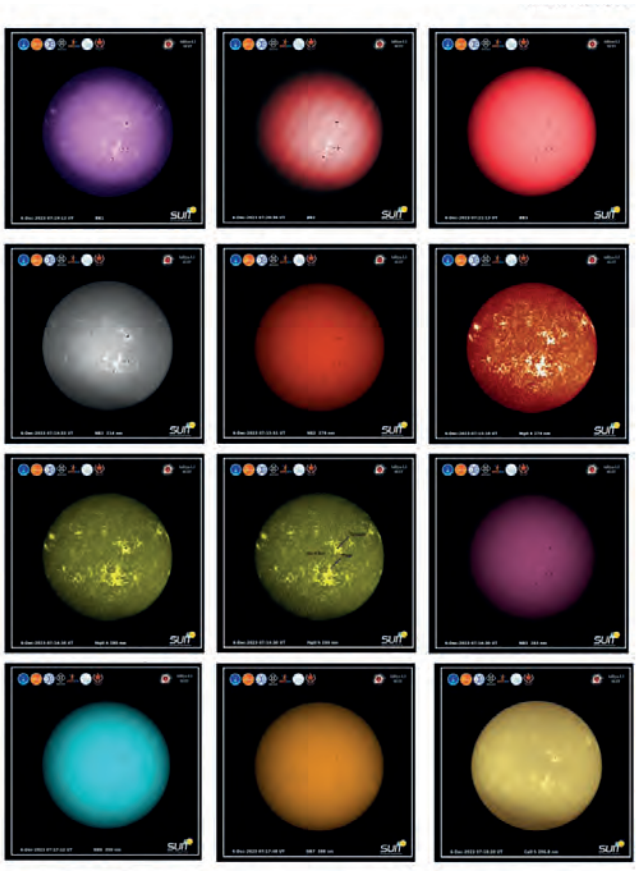
In the recently published *UN World Economic Situation and Prospects 2024* report, Bharat is projected to be the fastest-growing major economy in the world, showing growth of around 6.2%. That is not it. By the end of yet another celebration this year, the 2024 General Elections, India would have become a 4 trillion dollar economy, and well before the next government completes the middle of its 5-year term, India would have added another trillion dollars to its global macroeconomic stature. These are unprecedented numbers for a civilizational democracy. The last time such growth was shown, was by the communist autocracy of China, in the early 2000s, entirely propped by the West as its manufacturing backyard. China manufactured for global greed at scale, and it then used the same ability of scale manufacturing to challenge Western brands. India is eyeing to become a global manufacturing hub, but does it want to compete with China's scalability? No.

India's growth, in 2024 and thereafter, will largely happen through inward exploration. Please don't misinterpret it as an insular or protectionist growth. Bharat is not just a fast-growing economy, it is a fast-growing economy with

a resurgent civilization. The monies that will be invested by the government, the private entities, and the citizenry will be towards excavating ancient knowledge and wisdom, one that has sustained the erosion of time and the attacks of opposing forces. None of this is wishful thinking.

MAKING SCIENCE WORK FOR BHARAT

We, the people of Bharat, are building new knowledge-creating institutions and are getting adept at it. Institutions, both universities and small think tanks, are exploring ways to view modern sciences from the prism of Bharatiya Knowledge Systems (Indian Knowledge System). There is a purpose to this. Bharat is no longer interested in financing or encouraging deracinated scientists who blindly seek solutions for the nation's challenges in the West. Indeed, science diplomacy is about the exchange of best practices, but for many years a substantial section of Indian academia has performed their duties of 'Brown Sahibs' very well, marketing the West, China and the Soviet Union as the sole provider of solutions. Being unaccountable, being spendthrift on taxpayers' contributions, and generating half-baked and shoddy research is what the 'Brown Sahibs' could do. What changed? With a strengthening Indian economy, the biggest benefactor of Bharatiya science, the government has become smarter. It now wants the industry to be an equal benefactor of India's scientific pursuits. At no point in time after 1947, any Bharatiya government has encouraged academia-industry relations than it is doing now. A more productive and competitive private sector will only seek solutions from those scientists who really can contribute to them and the socio-economic causes they work on. A lot of redundant scientific workforce is about to be shown the door, and the only saving grace is their performance and output.



Aditya-L1's SUIT captures full-disk images of the Sun in near untraviolet wavelengths

A scientist will have to contribute to the industry, to the government, to society, to their nearest municipal corporation, to schools, and colleges, or have an innovation streak through the startup mode. There is no room for those who have been uneconomical. Bharat recently became the first to land on the southern pole of the Moon, it became one of the few countries to reach the Lagrangian Point, its ability to contain a global pandemic and manufacture vaccines at scale and send them globally, its ability to make bumper agricultural output, are all achievements big and small that only raise the stature of Bharat. Great science from our country will inspire the new generations. But where does great science come from? It will only come from spirituality, from the realization of the bigger causes of humankind, and the comprehension of the civilizational trajectory. Such a realization or comprehension happens *en masse* hardly once a century.

2024 is a turning point for Bharat, only for one reason — the *pranpratishthapana* of Prabhu Shri Ram in Ayodhya. The spiritual impact of this event will be etched on whatever pursuits the nation will take. The ability to reinstate ideals after centuries of onslaught is something that has not come to all civilizations that have gone long by and have not resurrected. The event will make us think of times before that modern historians have blatantly ceased to discuss. It will make us think about the ideals of what best qualities our nation can imbibe as we progress. It will push us to seek inspiration from idols of our civilization whose greatness has been acknowledged across lands and oceans.

India's knowledge-generation abilities do not reside within the anodyne and brutalist buildings — they reside in the beautiful temples, the economies that take shape around these temples, the guilds that work around them and the gurus that bridge the real with the metaphysical. A resurgent seat of Shri Ram in Ayodhya will be a civilizational turn-around for Bharat. Shri Ram will bridge science with spirituality in tangible ways for the Ganrajya and intangible and metaphysical ways for our Sanskriti.

**The writer is Associate Professor, Department of Physical and Natural Sciences & Chair, FLAME Center for South & Southeast Asia Studies, FLAME University; editor, Interstellar; and consultant, Science Diplomacy, Research and Information System for Developing Countries, India.*

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Linguistic Heritage of India: PANINI AND HIS ASHTADHYAYI

The structure of Panini's grammar anticipated the idea of a computer program by 2,500 years, a mighty proof of the scientific temperament of ancient Indians that the present generation must reconnect with

■ **Prof VPN Nampoori**

When the rest of the world was in dark, India was illumined with multi-field knowledge like linguistics, astronomy and mathematics, architecture and town planning, material science, agriculture, health science, etc. The science of language or linguistics was well developed in India, rules of which were compiled by Panini in *Ashtadhyayi* while the West had to wait for more than 2000 years to sow seeds for linguistics or philology.

Although India had many linguists like Yaska, Yajnavalkya and others, three are prominent: Panini, Pingala and Bhartrhari, whose works respectively *Ashtadhyayi*, *Chandasutra* and *Vakyapadiya* laid the foundations for the strong mansion of Indian grammar. This article will provide an introduction or a bird's-eye view of their valuable contributions. It was Noam Chomsky who once opined, "My contribution to mathematical linguistics has the root developed in India centuries ago by Panini's *Ashtadhyayi*."

Man belongs to a species with a social ability called language through which events can be shaped in each other's brain, and in an exceptional brain with good precision. Simply by making mutually agreed sound with our mouths, new ideas can arise in one another's brain and mind. This ability comes to us so efficiently and naturally that we forget the astonishing capabil-

Images Courtesy: Internet

ity of the power of language exhibited through our verbal and written capabilities. These capabilities bridge the gap between populations separated in space and time.

In the following sections, we will discuss the work of Panini and his magnum opus *Ashtadhyayi*.

'GREATEST MONUMENT OF HUMAN INTELLIGENCE'

The greatest success a constructive approach to the description of a natural language has ever had was when Dakshiputra Panini devised his grammar for the Sanskrit language, an achievement termed by the famous linguist Leonard Bloomfield as "one of the greatest monuments of human intelligence". We would expect that the insights of Panini as Frits Stall points out, "the greatest linguist of antiquity, if not of all time." The knowledge representation methodology in the grammar of Panini and his successors is in many ways equivalent to the more powerful, currently researched Artificial Intelligence (AI) schemes.

Ashtadhyayi consists of a little under 4,000 rules and aphorisms. Panini's grammar begins with meta-rules, or rules about rules. To facilitate his description, he establishes a special technical language, or meta-language. This is followed by several sections on how to generate words and sentences starting from roots, as well as rules on transformations of structure. The last part of the grammar is a one-directional string of rules, where a given rule in the sequence ignores all the rules that follow. Panini also uses recursion by allowing elements of earlier rules to recur in later rules. This anticipates in form and spirit by more than 2,500 years the idea of a computer program. The structure of this part of Panini's grammar should rightly be termed the Panini Machine.

In Panini's system, a finite set of rules is enough to generate an infinity of sentences. The algebraic character of Panini's rules was not appreciated in the West until a similar generative structure was discussed by Noam Chomsky and others. Despite similarities between Paninian and modern generative grammars, there exist striking differences as well. Some of these differences are related to the nature of the languages under study: Sanskrit and modern European languages.

Panini took the idea of action as defined by the verb and developed a comprehensive theory by providing a context for action in terms of its relations to agents and situation. This theory is called the Karaka theory. Panini introduced seven basic semantic notions that capture several aspects of action through its participants. These *karaka*s describe relations between words in a sentence so as to generate meanings. As Bhatrhari says: '*Jnanam sarvam sabdena bhasate*' (knowledge is illumined through sound).

AI AND PANINIAN APPROACH

The current knowledge representation systems of AI agree with the requirements of the Paninian approach. This makes analysis systematic once the knowledge in a text has been represented. However, this does not answer the question of a successful extraction of knowledge because, as has been indicated, natural language is full of various kinds of ambiguity. There are two different ways one can face this issue squarely. One may use Sanskrit as an intermediary natural language because its grammar is exhaustive. As a sentence grammarian, Panini describes structure of a sentence in *Ashtadhyayi*. A sentence gives an idea in a single unit of expression using qualifying words such as different cases and adverbs or causal agents for activity. A sentence is described using *karaka* defined by Panini as *karoti iti karaka*. To get a mathematical structure, sentence can be written as a functional form as S = S (S, O, V, R) where variables inside the brackets are subject, object, verb and interaction. In most of the languages, variables have a strict order. Indian languages break this symmetry by destroying the order like *Raman Ravanne konnu* (Raman Ravanan(ne) killed) or *Ravanane Raman konnu* (Ravanan(ne) Raman killed).

The Karaka theory of Panini describes a varied number of word patterns that can be generated from a sentence. Language is described by Panini at different levels in which a *karaka* is one among them as surface level, *vibhakti* level, *karaka* level, semantic level (what speaker has in mind). Using a mathematical structure, sentence S can be written with a noun (A) and verb (B) as S = A (k) B, k being the *karaka* relation between A and B. For example, a sentence *kutty kaikondu pazham thinnunnu* (child eats fruit with hand) can be represented as A (child, *pazham, kai*) ◊ *karaka* B (*thinnunnu*), which implies that the noun groups combine with verb through *karaka* relations. The sentence has two meaningful structures:

1. *Kutty kaikondu, pazham thinnunnu (subject (kartha, kutty), karanam (instrument, hand), object (pazham (karmam)), verb (thinnunnu (action, kriya).*
2. *Pazham kutty kaikondu thinnunnu (subject (pazham), object (kutty) kaikondu (karanam) thinnunnu (v)).*

Both are grammatically accepted but with different meaning through stresses provided. In the first case, it is Kutty who is eating the fruit, while in the second case, it is the fruit that the child is eating. Karaka modifies the words in a sentence to provide different meanings.

There are seven rules of *karaka* by

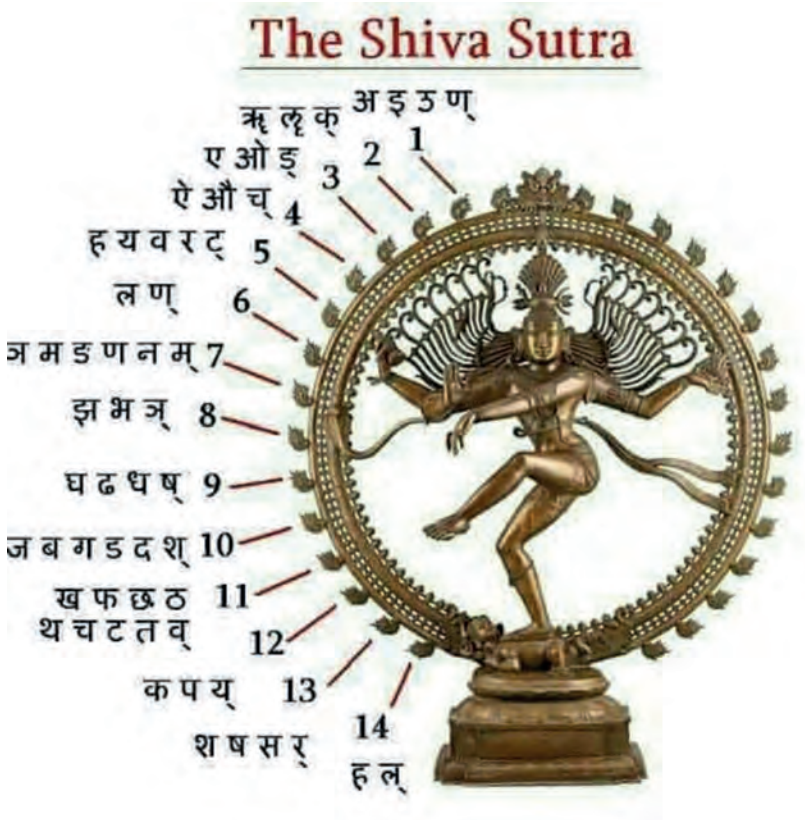

Image Courtesy: Sanskrit Panini Vyakarana

Maheswara Suthrangal or Shiva Sutra were devised by Panini. These are a set of 14 aphorisms devised as an arrangement of sounds for the purpose of grammatical exposition of the Sanskrit language

which sound represents sentences with the structure of subject, verb, object.

1.Karthru karakam, (Raman padikkunnu, Raman studies)

2. Karma karakam, (Krishnan ramane padippikkunnu, Krishnan teaches Raman)

3. Sakshi karakam (River samudrathinodu cherunnu, River joins the sea)

4.Swami karakam, (Amma kuttykku bhakshanam nalkunnu, Mother gives food to the child)

5.Kaarana karakam, (Dukhathal mizhikal niranju, Eyes were filled due to sorrow)

6. Adhikarana karakam (Amma noolukondu ketti, Mother tied with thread).

7. Adhikarana karakam (Ambalathil poyi, went to temple)

Note that except the *karthru karaka*, all other *karaka* modify the words with appropriate *prathyaya*s or modifier. Such modifiers are called *vibhakti* in Sanskrti grammar.

SANDHI: PANINI'S RULES FOR WORD COMBINATIONS

Sandhi is another important contribution of Panini to the growth of language. When two words are widely separated in script or in talk, they will keep their individuality. As they come closer and cross a particular separation, their nearness makes them to combine to create a compound word by creating appropriate changes in the words by the technique of *sandhi* as detailed by Panini in his *Ashtadhyayi*. The compound words will not have any property of the component words. This is similar to the formation of molecules by combining two or more atoms. The created compound will not have any property of the combining atoms. For example, when atoms of hydrogen and oxygen combine, the water molecule is created which can be represented as hydrogen + oxygen = water. Under normal conditions, hydrogen and oxygen are gases while water is a liquid. To cite an example of compound word formation, see the following:

Vannu (came) + irunnu (sat) = vannirunnu (had come). The meaning of the compound word is different from those of the component words. The compound words in most of the languages are formed by including connectors between words like 'hands and legs'. Whereas in Sanskrit and other Indian languages, compound words can be generated without using any connectors, like: *kaikalukal* (*kai kalukal*; hands and legs) or like *anamayilottakam* (*ana mayil ottakam*; elephant and peacock and camel) or *ganapativahanaripunayana* (*ganapati vahana ripu nayana*; eyes like those of the enemy of the vehicle of *ganapati*). Such techniques of Panini are called *samasthapadangal* and is a unique property of Indian languages.

PRATYAHARAS OR MAHESWARA SUTHRANGAL

Panini devised 14 Pratyaharas or Maheswara Sutrangal to represent Sanskrit alphabets which is similar to the steps followed in Fortran computer language — variables and flag to represent variable list. (Variables in Maheswara Suntrangal (MS) are the Sanskrit alphabets.)

For example, MS 1: a i u n (a first letter and u vowels; and last letter flag n (consonant not in the list-flag)

This represents the alphabets a , i , u.

Another MS: ai au c (vowels ai, au flag c) representing vowels ai, au

When these two MS are combined, we have (a c) representing all vowels a, i, u, r, e, ai, au.

Another MS ha l represents the letter ha. Then a l represents all the vowels and consonants in the Sanskrit language. No other language has MS type simple techniques to represent respective classification of alphabets. All the 14 Maheswara Suthrangal all given in the figure (above).

CONCLUSION

We discussed Panini's *Ashtadyayi* as the science of language which is a gift of India given to the branch of language studies. There are gaps in the subject which make it necessary to do more research in this field. It is necessary that Indian Knowledge System has to be included in school and college syllabus as an optional subject to start with.

**The author is Visiting Scientist, Cochin University of Science and Technology, Kochi. He can be reached at nampoori@ gmail.com.*

Regular meditation, yogic breathing, and *asana*s can bolster cardiovascular health and combat stress, the precursor of many illnesses and mortality

Image Courtesy: Freerangestock.com

WELLNESS

Embracing Yoga to Tackle NCDs

Yoga might be the answer to address numerous public health issues in India, including the rising incidence of NCDs or non-communicable diseases that cause 66% of fatalities in the country annually

■ Dr Indranill Basu-Ray

As we confront an impending global health catastrophe, an insidious threat remains largely unnoticed. Non-communicable diseases (NCDs) are this hidden menace, responsible for 70% of global deaths each year. The scenario in India mirrors this, with NCDs causing 66% of its fatalities. Every percentage point in these statistics symbolizes a life lost prematurely, families devastated, and communities grieving. This alarming situation demands urgent attention and innovative solutions. Interestingly, the answer might lie in an age-old practice familiar to many: Yoga.

STRESS IS LINKED TO NON-COMMUNICABLE DISEASES

While many perceive Yoga primarily as a mystical or spiritual discipline, it's essential to recognize its broader implications. While it's spiritual roots are undeniable and contribute to its healing power, let us take a look at the scientific evidence that highlights yoga's medicinal benefits.

In India, an alarming 77 million adults are contending with diabetes, with another 25 million on the verge of this condition, termed prediabetics. As per Apollo's Annual Health of the Nation reports, which align with WHO findings, NCDs have surreptitiously become the primary cause of death, leading to 66% of India's mortality rate.

A comprehensive survey of urban elderly Indians revealed that 71% were dealing with at least one NCD, and 40% were managing more than two. This data paints a distressing picture for our senior citizens, who should be relish-

ing their retirement years rather than wrestling with illnesses. The situation is even graver for the younger generation, with the Indian Council of Medical Research indicating a 26% mortality risk between ages 30 and 70 from the four main NCDs.

EMPIRICAL EVIDENCE: YOGA'S ROLE IN HEART HEALTH AND DIABETES CONTROL

Recent clinical research and medical studies have delved deeply into yoga's impact on non-communicable diseases, uncovering promising results, particularly in the realm of cardiovascular health and diabetes management.

Cardiovascular health, a critical aspect of overall well-being, has been shown to benefit significantly from yoga practices. Research published in the *European Journal of Preventive Cardiology* has shed light on yoga's potential in combating heart disease. This research highlights how yoga contributes to mitigating key risk factors such as hypertension and elevated cholesterol levels. These findings are pivotal, considering the global burden of heart disease and its status as a leading cause of death worldwide.

The Mayo Clinic, a renowned medical research establishment, has also recognized the value of yoga in this context. Their endorsement of yoga, either as a standalone approach or in conjunction with traditional medical treatments, for managing heart disease and hypertension is a testament to its efficacy. This endorsement is particularly significant, as it comes from a mainstream medical institution, bridging the gap between alternative therapies and conventional medicine.

Furthermore, the role of yoga in diabetes management has been illuminated by a systematic review in the *Journal of Diabetes Research*. This review underscores yoga's positive effects on glycemic control, a crucial factor in the management of type 2 diabetes. By improving glycemic control, yoga helps in regulating blood sugar levels, which is vital for preventing the long-term complications associated with diabetes.

Harvard Medical School, another esteemed institution, advocates for the inclusion of yoga in managing conditions commonly linked to NCDs. Their focus extends beyond diabetes and heart disease to include chronic conditions like lower back pain, which is often associated with obesity. The school's support for yoga in this area is based on evidence that yoga not only helps in alleviating pain but also addresses the underlying factors contributing to these conditions, such as poor posture and lack of physical activity.

These findings collectively emphasize yoga's promise as a therapeutic strategy for NCDs. The benefits of yoga in managing and preventing these diseases are multi-faceted. It not only addresses the physical aspects of these conditions but also contributes to mental and emotional well-being, which is often compromised in chronic disease scenarios.

Image Courtesy: Shutterstock

Image Courtesy: PIB

A VERSATILE TOOL IN PUBLIC HEALTH

The implications of these studies are far-reaching. They suggest that yoga, a practice that is accessible, affordable, and non-invasive, can play a significant role in the global fight against NCDs. This is particularly relevant in low-resource settings where access to traditional healthcare is limited. By incorporating yoga into public health strategies, we can make a substantial impact on the prevention and management of these diseases.

Moreover, these studies pave the way for further research into the mechanisms by which yoga affects these conditions. Understanding the physiological and psychological pathways influenced by yoga can help in refining yoga therapies to be more targeted and effective.

For seniors, who are disproportionately affected by NCDs, yoga shines as a ray of hope. Its gentle poses and conscious breathing techniques can help manage chronic ailments, boost mobility, and elevate overall well-being. The goal is not just longevity but ensuring those years are filled with vigor and health. Yoga's adaptability makes it suitable for various age groups and physical abilities, offering modified poses and practices that cater to individual needs and limitations. This inclusivity underscores yoga's role as a versatile tool in public health, capable of improving life quality across different demographics.

Yoga's adaptability extends to its application in various settings and life-

Group yoga sessions can foster a sense of community and support, essential for mental health

styles. In modern times, where lifestyle diseases are rampant, integrating yoga into daily routines can be a game-changer. The beauty of yoga lies in its simplicity and the minimal requirement of resources. Whether it is a few minutes of stretching at the office or a short meditation session before bed, these practices can significantly reduce the risk of lifestyle-related diseases.

Stress, often cited as a contributing factor to many NCDs, can be effectively managed through yoga. Techniques like deep breathing, mindfulness, and relaxation poses are not only beneficial in reducing stress but also in enhancing emotional resilience. By incorporating these practices, individuals can develop a more robust defense against the pressures of modern life.

Moreover, the economic implications of widespread yoga practice are profound. By reducing the incidence of NCDs, yoga can significantly lower healthcare costs for individuals and governments. This cost-effectiveness makes yoga an attractive option for public health initiatives, especially in countries grappling with the high costs of healthcare.

FROM INDIVIDUAL HEALTH TO COMMUNITY WELL-BEING

Yoga's potential extends beyond individual health to community well-being. Group yoga sessions can foster a sense of community and support, essential for mental health. These sessions provide a platform for social interaction and collective healing, contributing to the overall health of the community.

However, despite this compelling evidence, yoga remains underutilized in healthcare, often relegated to the realm of mere exercise or 'alternative' therapy. The robust data supporting yoga's health advantages cannot be ignored. The challenges hindering yoga's incorporation into mainstream healthcare are significant but surmountable. We must champion yoga's role in healthcare, integrate it into medical systems, educate the masses about its merits, and equip healthcare workers to apply it.

Incorporating yoga into conventional healthcare transcends health concerns; it's a matter of social equity. It offers an affordable, accessible, and sustainable remedy that can uplift both individuals and communities. This healthcare revolution, with yoga at its core, empowers people to proactively manage their health.

Facing the escalating NCD crisis, we must acknowledge yoga's transformative potential in health and wellness. With its comprehensive approach to mental and physical health, yoga presents a distinctive strategy for disease prevention and more effective treatments, complementing conventional medical care. We must also further invest in research to delve deeper into yoga's advantages and confirm its efficacy in preventing and managing NCDs. This journey is not merely about adopting an ancient technique but about evolving modern healthcare to be more holistic, patient-centric, and efficient.

CHALLENGES TO YOGA'S ROLE AS HOLISTIC MEDICINE

For yoga to truly evolve into holistic medicine, three challenges must be addressed. Firstly, yoga is a blend of breathing exercises, mindfulness, meditation, and physical poses, not just the latter. Limiting oneself to only the physical aspect will yield limited benefits. Secondly, the spiritual essence and philosophy of yoga are crucial to unlock its full potential. Spirituality is distinct from religiosity, so any misconceptions of yoga being a religious ritual are baseless. Lastly, public discourse on yoga should be rooted in knowledge and evidence, rather than blind faith or adherence to rituals and unverified spiritual leaders.

Now is the moment to embrace yoga wholeheartedly. Regular meditation, yogic breathing, and *asana*s can bolster cardiovascular health and combat stress, the precursor of many illnesses and mortality. The integration of yoga into daily life, even in small increments, can lead to significant health improvements. Encouraging a routine that includes mindful breathing or short meditation sessions can foster long-term well-being and resilience against diseases.

As we face the growing challenge of NCDs, yoga offers a holistic and effective approach to health and wellness. By addressing the physical, mental, and emotional aspects of well-being, yoga can play a pivotal role in preventing and managing these diseases. However, to fully realize its potential, we must overcome the challenges in mainstreaming yoga, invest in research, and educate the public about its benefits.

**The author is a Cardiac Electrophysiologist and a Professor of Cardiology and Public Health, based in Memphis, Tennessee, USA. He is the Founder Chairman of American Academy for Yoga in Medicine.*

PROFILE OF THE MONTH: Dr PALPU PUSHPANGADAN (B. 23 JAN 1944)

A Trailblazer of Sharing Benefits of Traditional Knowledge

In an age when scientific achievements are instantly monetised for personal gains, Padma Shri Dr Palpu Pushpangadan pioneered sharing the benefits of traditional knowledge with indigenous communities that have owned it for centuries

■ Dr Biju Dharmapalan

Image Courtesy: gitamritam.com

Prof (Dr) Palpu Pushpangadan, who served as the director of National Botanical Research Institute, Lucknow; Central Institute of Medicinal and Aromatic Plants, Lucknow; Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram; and Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI), Palode, is a multi-faceted personality who has brought the subject of ethnobotany and traditional knowledge to the forefront.

STEPPING STONES TO GATHERING KNOWLEDGE

This pioneer was born to P Palpu and K Meenakshi on 23 January 1944 at Prakkulam in Kollam district in Kerala as their eighth son. After completing his BSc in Botany from SN College, Kollam, he joined the Aligarh Muslim University for his MSc and completed the course in 1967. During his studies at Aligarh, he was fascinated by a lecture by Dr MS Swaminathan and decided to stay in research instead of joining the position of lecturer offered to him. In 1968, Pushpangadan joined as a Junior Research Fellow (JRF) at the Regional Research Laboratory (RRL), Jammu, (now known as CSIR-Indian Institute of Integrative Medicine), under Dr EK Janaki Ammal, the renowned botanist and plant cytologist. She taught him the basics of cytological preparation. In 1969, he got a permanent position with RRL, Jammu, as a Junior Scientific Assistant and was placed at Srinagar Laboratory. He was later promoted to Senior Scientific Assistant in 1974.

The desire to do PhD was emerging during that period, but no recognised supervisors were available at RRL, Jammu, at the time. As per his

professor's advice, he took leave from RRL and joined the newly started interdisciplinary MPhil course at Aligarh Muslim University (AMU). He was the first MPhil student who completed the course from AMU with interdisciplinary subjects such as Biochemistry and Genetics in 1972. In the meantime, Prof Reyat Khan helped Pushpangadan to recognise RRL Jammu, as a Research Centre and Dr SN Sobti (Botany) and Dr CK Atal (Biochemistry and Pharmacology) as research guides of AMU. In 1975, Pushpangadan received PhD in Cytogenetics, Plant Breeding and Biochemical Genetics under the guidance of Prof Khan, Dr Sobti and Dr Atal.

After completing his doctoral programme, Dr Atal recommended his name for the Chief Coordinator in All India Research Project on Ethnobiology (AICRPE) under the Ministry of Environment and Forest (MoEF). Under Dr Pushpangadan's leadership, extensive data on the ethnobiological uses of about 10,000 Indian plant species were collected. These massive data were enumerated and analysed, and a database was created for all those interested in Ethnobiology, Ethnomedicine and Ethnopharmacology.

Image Courtesy: Wikimedia Commons

During Dr Pushpangadan's tenure as the director, JNTBGRI recognised the contribution of Kani tribals in imparting knowledge about the medicinal properties of Tricopus zeylanicus (*arogyapacha*)

TRANSFORMING A GARDEN INTO A RESEARCH CENTRE

In 1990, he was selected as the Director of Tropical Botanic Garden and Research Institute (TBGRI), Palode, Thiruvananthapuram, and transferred the whole AICRPE programme to TBGRI. When Dr Pushpangadan joined TBGRI, it was only a garden system. He transformed the institute into a nationally recognised research centre, particularly for scientifically validating medicinal and aromatic plants and for the conservation of the biodiversity of Western Ghats. New divisions of Biotechnology, Conservation Biology, Systematic Botany, Phytochemistry, Ethnopharmacology and Ethno Medicine were created for this. He introduced the concept of establishing Field Gene Banks in Botanic Gardens. He established the first Field Gene Bank of Medicinal and Aromatic plants at JNTBGRI at Thiruvananthapuram in 1993. He collected about 210 Rare, Endangered and Threatened plant and tree species from the Andaman and Nicobar Islands and introduced them at TBGRI. This helped conserve these plants from the tsunami of December 2004.

UNPRECEDENTED SHARING OF IPR

It was during his tenure as director that TBGRI broke new ground, recognising the contribution of Kani tribals who imparted knowledge about the medicinal properties of Tricopus zeylanicus (*arogyapacha*), a plant in the forests of Western Ghats. Dr Pushpangadan and his research team, then located at Regional Research Laboratory (RRL), Jammu, carried out basic phytochemical and pharmacological properties and validated the claims of the tribal community. Dr Pushpangadan and his team later at TBGRI, Kerala, developed a scientifically validated and standardised herbal formulation — which after necessary pharmacological, toxicological and clinical evaluation was released for commercial production in 1996 under the trade name 'Jeevani'.

Dr Pushpangadan, who was then the Director of TBGRI, with the approval of competent authority agreed to share the benefits derived from this technology with the Kani tribe on a 1:1 basis. It was for the first time in the world that a scientific institution had come forward to recognise the intellectual property rights of indigenous communities.

In May 1996, the Geneva meeting of the United Nations Environmental Programme approved the TBGRI model of equitable sharing of the benefits from utilisation of traditional knowledge implemented the Article 8(j) of the Convention on Biological Diversity (CBD). In most cases, native people around the world are completely exploited for their medicinal knowledge, receiving little or nothing in return.

The TBGRI Model has gotten wider acclaim and acceptance the world over, because it was the first of its kind to recognise community rights and IPR of a

Image Courtesy: Wikimedia Commons

In 1990, Dr Pushpangadan was selected as the director of Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI) in Palode, Kerala. He transformed it into a nationally recognised research centre

traditional community by sharing equitably the benefits derived out of the use of knowledge that has been developed and preserved by that community for generations. Further, it demonstrates the vast and as yet under-explored potential of the Indian traditional knowledge systems, particularly the traditional health care practices of the local and indigenous people in India.

Kani tribe was then a totally unorganised forest dwelling semi-nomadic tribe. The prime concern in the beginning was, therefore, to evolve a viable mechanism enabling the tribe to receive such funds and utilising the same for the welfare of the community. With the help of local NGOs, Dr Pushpangadan and his colleagues along with some motivated government officials were able to educate and encourage them to form a registered trust, Kerala Kani Samudaya Kshema Trust (KKSKT) with only Kani adults as its members. The trust is fully owned and managed by the Kani tribe. Over 70% of the Kani families of Kerala are now members of this trust. As per the rules of the trust, the license fee and royalty received on account of the sale of 'Jeevani' drug will be in a fixed deposit and only the interest accrued from this amount will be utilised for the welfare of the Kani tribe.

THE KANI MODEL

This model was thus developed and perfected over a period of about 12 years, 1987-99, in full consultation with the Kani tribe. In fact, the whole process of this benefit sharing started much before the CBD was evolving. It took almost three years for the Kani tribe to receive this benefit. All along these years, starting from 1987, it was the mutual trust, respect, transparency and frequent interaction and communication between TBGRI and the Kani tribe that contributed to the success of this benefit-sharing model.

In addition to the license fee and royalty that Kani Trust is receiving, a large number of Kani families are now getting benefits from the cultivation of Arogyapacha and supply of the raw-material (i.e., the leaves of the plant) to the pharmaceutical company for the production of the drug. TBGRI has trained many tribal families for the cultivation of Arogyapacha in and around their dwellings in the forest.

The sharing of benefits with the Kanis and the formation of the Kani trust fund have started showing positive impacts in the sense that the tribal community is now becoming conscious about the values of and rights over their knowledge system and associated biological resources. These developments have also helped in bringing the Kani families to a single organisational framework, so that the benefits accrued from the trust fund could be utilised for the economic well-being and social development in the Kani tribal hamlets. Looking back, it is unbelievable to see the kind of transformation of this otherwise timid, nomadic forest dwelling tribe who used to be scared of outsiders. They now stand up with dignity and claim their rights and privileges. The quality of their life has been tremendously improved.

The TBGRI Model is perhaps a unique experiment ever done, wherein the benefits accrued from the development of a product based on an ethnobotanical lead were shared with the holders of that traditional knowledge. Considering the significant outcome of this model in community empowerment, income generation and poverty eradication of a tribal community, Pushpangadan was awarded the UN-Equator Initiative Prize (under the individual category) at the World Summit on Sustainable Development held in Johannesburg in August 2002. Dr Pushpangadan has decided to utilise the award money to institute an annual award, the 'Pushpangadan Biodiversity Access & Benefit Sharing Award,' to recognise the people who have substantially contributed to the welfare of the tribal community. He has entrusted CSIR-NBRI, Lucknow, to select the award winners and distribute the prizes at a special ceremony to be organised by NBRI, annually. For his contributions, the government of India honoured Prof Pushpangadan with the coveted Padma Shri award in 2010.

**The writer is a science communicator and an adjunct faculty at the National Institute of Advanced Studies, Bengaluru. He can be reached at bijudharmapalan@gmail.com.*

HERB HERITAGE

The Many Powers of Inconspicuous Giloy

A herb whose potent medical properties are known to Indians since ancient times was reborn in popular imagination during COVID-19 pandemic

■ Vaidya Preeti Bhosle

Image Courtesy: Shutterstock

During the *samundra manthan*, a pot full of *amrit* came out from the sea, some people took it and ran away. Few drops of *amrit* fell on the earth and took the form of a climbing shrub.

Dhanvantari Nighantu (Ayurveda classical literature) mentions in chapter 3.1, verse 1-5 :

यदा लंकेश्वरो मानी रावणो राक्षसाधिपः । रामपत्नीं वनात्सीताम जहार मदनातुरः ॥

ततस्तं बलवान रामो रिपूंजयापहरिणम । वृतो वानरसैन्येन जघान रणमूर्धिन ॥

हते तस्मिन् सुरारातो रावणे बलगर्विते । देवराजः सहस्राक्षः परितुष्टो हि राघवे॥

तत्र ये वानराः केचिद राक्षसेर्निहिता रणे । तानिन्द्रो जीवयामास संचिचयामृतवृष्टिभिः ॥

ततो येषु प्रदेशेषु कपिगत्रतपचरियुताः । पियूष बिन्दवः पेतुस्तेभ्यो जाता गुडूचीका ॥

During the fierce war between Rama and Ravana, Rama won the battle against the king of Lanka, Ravana (who had captured Sita). Several monkey warriors were killed. At that time, lord Indra sprinkled an elixir over their bodies and provided them rebirth. Wherever the drops of that elixir fell on earth, a shrub originated. This shrub was called *guduchi*.

GILOY IN ANCIENT TEXTS

Atharva Veda mentions that this very plant was kept in every household to avoid snakes and scorpions. Being none other than the mighty Giloy, this plant is often referred to as 'amrita' for a variety of reasons.

Its usage in almost every part of Bharat is evident from the fact that it has nearly 23 vernacular names in 11 regional languages. Various ancient texts of Indian System of Medicine, Ayurveda, describe the functions of Giloy with different synonyms, viz., *avyatha, amrita, amrtavalli, kundali, guduchika, gundra, chakrangi, chakra lakshana, chandrahaasa, jivantika, jvara nashini, jvaraari, tantrika, deva nirmita, dhara, naaga kanyaka, naaga kumarika, bhishakapriya, mandali, madhuparni, rasaayani, vatsaadani, shyaama, vayastha, varaa, surakrita, soma, somavalli.*

It is fondly called Bhishak Priya (physician's favourite) because of its versatility. Ayurveda literary texts like *Charaka Samhita, Sushruta Samhita, Ashtanga Sangraha, Dhanvantari Nighantu, Shodhala Nighantu, Bhava Prakash Nighantu, Raja Nighantu, Dalhana*, etc. have minutely categorised various segments of health conditions where Giloy is used either as a single herb or as a compound formulation.

Broad classification of diseases / health conditions where Giloy is widely used (in different doses and different

dosage forms) are :
1. Jwara (different kind of fevers)
2. Trishna (thirst related disorders)
3. Vatarakta (a form of arthritic condition)
4. Pandu (liver/ blood disorder)
5. Kamala (jaundice/ liver disorder)
6. Daha (burning issues)
7. Prameha (urinary/ diabetic disorder)
8. Kushtha (various skin issues)
9. Chhardi (nausea/ emesis)
10. Krimi (worms infestation/ microbial infections)
11. Kandu (itching on various parts of body)
12. Rakta arsha (bleeding piles)
13. Medoroga (obesity/ fat accumulation/ hypercholesterolaemia/ hyperlipidaemia/ dyslipidaemia)
14. Visarpa (herpes/ skin disease of spreading nature)
15. Bhrama (hallucination/ illusion/ state of confusion/ perplexity/ state of errors)
16. Kasa (different forms of cough)
17. Jara vyadhi (geriatric issues) etc.

Aerial roots of Giloy are thin yet so strong that Acharya Sushruta used it for suturing surgical wounds. It acted as a very strong thread thereby preventing wound from rupturing. Along with this, it helped in faster wound healing because *guduchi* has very strong healing properties.

It is not just Indian physicians, European physicians too have widely used Giloy as a valuable tonic, anti-pyretic, diuretic, etc.

The COVID-19 pandemic witnessed extensive use of *guduchi* as protective/ preventive/ curative/ immunomodulatory herb across the globe in various forms like powder, extract, decoction of fresh plant/ dried plant, tablets, etc. and yes, it gave promising results as an adjuvant/ supportive/ solo therapy.

UNDERSTANDING GILOY

Guduchi grows as a climber with succulent stem. Botanically, it is known as Tinospora cordifolia and is a member of the family Menispermaceae, and is indigenous to the Indian subcontinent. Following parts of this plant are considered to be of medicinal use :

- Stem Powder - 3-6 gm*
- Stem Decoction (1/20) - 50-100 ml*
- Stem Infusion (1/10) - 30-60 ml*
- Stem Fresh juice - 10-20 ml*
- Stem Sattva (alkaline extract) - 1-2 gm*
- Leaf Powder – 3-6 gm*
- Areal Roots Decoction – 50-100 ml*

**or as advised by physician*

Ayurveda pharmacology describes its phytochemical/ pharmacological properties as :

- Rasa - Tikta (bitter), Kashaya (astringent)
- Guna - Guru (heavy), Snigdha (oily)
- Virya - Ushna (hot potency)
- Vipaka - Madhura (sweet post digestion)
- Karma - Tridosha shamaka, medhya, rasayana, dipaniya, grahi, medohara, kandughna, jvarahara, daha prashamana

A lot of scientific studies have been carried out on western parameters on Giloy, which clarify the mode of action of *amrita* and further substantiate its potency as well as efficacy. Some of those studies are listed as :

- **Cancer prevention:** Giloy shows the highest free radical scavenging action (around 70%) along with reducing the number of drug resistant cancer cells. It is a potential therapeutic vector for degenerative disorders induced by free radicals.
- **Protection against oxidative damage:** The presence of phytochemicals such as polyphenols and tannins contribute to this property. Guduchi possess radioactive properties. Leaf and stem extract also offer considerable protection against plasmid DNA damage and protein oxidation caused by free radicals.
- **Diabetes prevention:** Giloy stem works as an anti-diabetic medication through inducing oxidative stress, boosting insulin production by reducing gluconeogenesis and glycogenolysis. The presence of Alkaloids (Magnoflorine, Palmetime, Jatrorrhizine), tannins, cardiac glycosides, flavonoids, saponins, and steroids is thought to be responsible for anti-diabetic benefits.
- **Strengthening heart and improving heart health:** Guduchi contains an alkaloid (berberine) that has cardiovascular protective properties. Berberine improves health by lowering endothelium infection.
- **Anti-inflammatory effect:** The presence of alkaloids and flavonoids in *amrita* methanolic extract inhibited COX and LOX enzymes, resulting in anti-inflammatory action.
- **Anti-bacterial activity:** Giloy extract inhibits bacterial growth and increases neutrophil phagocytic and intracellular bacterial capabilities.
- **Pain-relieving effect:** Giloy is a healthier alternative to NSAIDs, which cause gastrointestinal discomfort, while *guduchi* has gastroprotective properties.
- **Allergies prevention:** Sneezing, nasal discharge, nasal blockage, and nasal pruritus are all significantly relieved by *guduchi*.
- **Improves Immunity:** Giloy contains chemicals such as tinocordioside, syrigin, etc., which have immunomodulatory and cytotoxic properties. These natural substances have been shown to improve macrophage phagocytic function. Guduchi and its component α-D-glucan induce the synthesis of many immune-stimulatory cytokines by stimulating NK cells, B cells, and T cells.

Besides the medicinal properties, *giloy* has an impressive nutritional profile which makes it a super herb as well. It contains a lot of micro & macro nutrients, like α-carotene, Niacin, Ascorbic acid, Tocopherol, Potassium, Chromium, Iron, Calcium, Zinc, Copper, Sodium, Magnesium, Iodine and Lycopene.

Although *amrita* is a house plant and has multiple benefits yet it comes with certain cautions, overconsumption / consumption without proper guidance can lead to constipation, stomach irritation, hypoglycaemia (low blood sugar levels), fatigue and dizziness.

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

All Images Courtesy: VIBHA

PHOTO FEATURE

Snapshots from Bharatiya Vigyan Sammelan 2023

The sixth edition of the festival brought special focus on environmental awareness

Science India Bureau

The 6th Bharatiya Vigyan Sammelan (BVS 2023), organised as a pre-programme of Vibrant Gujarat by the state government and Vijnana Bharati in association with the National Innovation Foundation, Department of Science & Technology, Government of India, and CSIR-National Institute of Science Communication and Policy Research (CSIR-NIScPR), was successfully held from 21-24 December 2023, in Ahmedabad.

The festival was inaugurated on 21 December by Gujarat Chief Minister Bhupendrabhai Patel in the presence of Balwantsinh Rajput and Praful Pansheriya, both ministers with the Gujarat government; Sunil Ambekar, Akhil Bharatiya Prachar Pramukh of Rashtriya Swayamsevak Sangh; and Dr Shiv Kumar Sharma, national organising secretary of Vijnana Bharati.

The primary objective of the event was to provide an excellent platform to integrate and showcase Indian traditional practices. The focal theme of this edition of BVS was: "भारत का विकास भारतीय मूल्यों और निप्रितन के साथ": A New Integral Vision for Development".

Over the course of four days, a comprehensive array of nine diverse programmes unfolded. The schedule included a total of 16 conferences, with special focus on environmental awareness. An engaging exhibition showcased the latest advancements in science and technology, while interactive sessions with scientists fostered a direct and insightful connection between experts and participants.

Vigyan Gurjari, Gujarat prant unit of VIBHA meticulously planned and executed the BVS 2023, which was hosted by Science City, Ahmedabad, and SAL Education.

Gujarat Chief Minister Bhupendrabhai Patel at an exhibit at the Bharatiya Vigyan Sammelan 2023 held in December in Ahmedabad

From left: Sunil Ambekar, Akhil Bharatiya Prachar Pramukh of Rashtriya Swayamsevak Sangh, Shekhar Mande, president Vijnana Bharati and former DG CSIR, and Dr Shiv Kumar Sharma, National Organising Secretary, Vijnana Bharati

Right: An exhibition engages the interest of young science buffs

Above: A session explaining scientific processes through sign language in progress; Right: Chairman of ISRO, S. Somanath, was popular among students and visitors

Left and below: The event was not only intellectually stimulating but also culturally rich, featuring diverse and captivating cultural programmes

Below: Students at a science seminar

Above: The BVS exhibition emphasised inclusivity, showcasing the rich diversity of grassroots innovation

CSIR-Central Salt & Marine Chemicals Research Institute, Bhavnagar, Gujarat

IN FOCUS: CSIR-CSMCRI, BHAVNAGAR

Self-sufficiency and Innovation: From Table Salt to Biostimulants

The CSIR-Central Salt & Marine Chemicals Research Institute that played a vital role in bringing taste to our food, is now at the forefront of innovation that uses marine wealth for bettering our lives

Among one of the 37 premier national laboratories of the Council of Scientific & Industrial Research (CSIR), CSIR-Central Salt & Marine Chemicals Research Institute (CSIR-CSMCRI), Bhavnagar has made significant contributions to technological excellence in its core mandate namely marine resources.

THE INNOVATION ENGINE OF INDIA

With the mandate 'Explore, harness and transform marine resources for the good of the people of India', CSIR-CSMCRI works in research areas including salt and marine chemicals, membrane desalination and separation, catalysis for marine organics, specialty inorganic materials, renewable energy, and waste-to-wealth creation processes. The institute also focuses on seaweeds, microalgae, and halophytes, their molecular biology and biotechnology and downstream processing to value-added products, saline waste management, environmental impact assessment, and building human resources to enhance the well-being of society and the nation on the whole. According to the 2023 Scimago Institutions Rankings, the institute is recognized as one of the best-performing national laboratories within and outside the CSIR fraternity.

■ **Dr Kannan Srinivasan, Dr Arup Ghosh, Dr Kanti Bhooshan Pandey**

CSIR-CSMCRI'S SIGNIFICANT CONTRIBUTIONS

Waste to value: The institute's recent major accomplishment involves the development of a complete 'Zero Waste' technological solution aimed at generating fertilizer-grade potash from both spent wash and incinerator ash, which are generated from molasses-based distilleries. A first-of-its-kind commercial plant has been successfully installed at Aurangabad Distillery Limited, located in Walchandnagar, Maharashtra. This plant is unique and unrivaled as it not

All Images Courtesy: CSIR-CSMCRI

only achieves Zero Liquid Discharge (ZLD) for the distilleries but also generates valuable by-products, providing opportunities for revenue generation on multiple fronts.

Seaweed cultivation and their downstream processed products: CSIR-CSMCRI is a leading innovator in seaweed cultivation techniques, including the raft method. In order to support rural coastal communities and provide a dependable source of income, the institute is currently engaged in a pan-India project to assess the feasibility of commercial seaweed cultivation and identify suitable locations. Various seaweeds, including *Kappaphycus alvarezii, Gracilaria edulis, G. dura, G. salicornia, G. verrucosa, G. debilis, Gelidiella acerosa*, *Ulva (Enteromorpha) spp. and Enteromorpha*, are being tested for their suitability. The institute has also developed a technology to prepare a hydrocolloid called kappa carrageenan and sap from *K. alvarezii* seaweed that has been validated across India as a powerful crop biostimulant. The technology has been licensed and is being made available to Indian farmers at an affordable price. The institute has also developed a liquid seaweed plant biostimulant (LSPB) using naturally and abundantly available brown seaweeds like *Sargassum wightii, Sargassum swartzii, and Sargassum tenerrimum*. The biostimulants are rich in essential agro-nutrients and are highly effective as plant growth promoters. CSIR-CSMCRI has also developed a zero-liquid-discharge (ZLD) technology for extracting alginic acid and its derivatives from *Sargassum*, which has been recently transferred. Furthermore, the institute has developed animal feed additives that not only improve the health and productivity of cattle and poultry but also reduce methane emissions from ruminants.

Above: The first commercial unit based on CSIR-CSMCRI's Spent Wash Management (SWM) technology, has been installed at Aurangabad Distillery Limited (60 klpd distillery at Walchandnagar, Maharashtra); Left: Mobile desalination plant serving water to the people of Gujarat after Tauktae cyclone in May 2021

Membrane, resins & materials for water desalination, and purification processes: The institute is at the forefront of developing eco-friendly membrane-based technologies for treating brackish, seawater, and industrial wastewater. With cutting-edge research on various types of membranes, including those used in reverse osmosis, ultra-filtration, nano-filtration, hybrid, hollow fibre water purification, and ion-exchange separation, CSIR-CSMCRI's technological prowess is also evident in the installation of standalone desalination plants both in coastal states of India and abroad. The institute's mobile water purification and desalination bus, which has been designed and developed indigenously, has provided essential support during natural calamities, serving in the past during various crises like floods, cyclones, earthquakes, etc. Recently, the newly designed mobile desalination van provided safe drinking water to people affected by floods in the Konkan Region of Maharashtra (2021) and cyclone damage in Rajula and Jafrabad of Amreli

From left: The Liquid Seaweed Plant Biostimulant from Brown Algae; a seaweed-based biostimulant for various crops; Sagarika, a sea product for crop productivity enhancement

district, Gujarat (2021). In addition, the institute is developing indigenous acid and oxidation-resistant cation exchange membranes that will support India's 'Hydrogen Mission'. The technology for the indigenous cation exchange membrane, benchmarked with the Nafion membrane, has been jointly developed with ONGC Energy Center Trust and recently transferred to GFCL Solar and Green Hydrogen Products Limited, Gujarat.

Skill and human resource development: CSIR-CSMCRI's skill development training courses, under the CSIR Integrated Skill Initiative, have earned widespread praise for their impact in the areas of solar thermal technology, soil and water testing, chemical process plants, fermentation, and seaweed cultivation and processing. The program promotes entrepreneurship and bridges the gap between academia and business. Over 125 programs have trained more than 4000 people in the past six years. To foster a scientific spirit among school students, CSIR Jigyasa has sensitized over 5600 students and 350 teachers in 2023-24 through different programs, bringing students and scientists together on the same platform. CSIR-CSMCRI provides opportunities for doctoral studies and has around 200-250 research students, with approx. 30 PhD degrees awarded each year. About 150 students are trained annually through different internship programs. AcSIR (Academy of Scientific & Innovative Research), the largest Academic Institution for doctoral research in India, at CSIR-CSMCRI, offers unique doctoral courses not covered by other Universities in India, like 'Salt Technologies', 'Membrane Technologies', 'Water and Wastewater Treatment Technologies', 'Algal Technologies', and 'Chemistry of Common Salt & Bittern Products'. The mandatory Societal Programs offered by AcSIR expose students to actual problems in society and encourage them to find solutions through scientific interventions. The above domains of research align with national programs and UN Sustainable Development Goals (SDGs), highlighting the institute's significant contributions in recent years for the good of the people.

**Dr Kannan Srinivasan is the Director of CSIR-Central Salt & Marine Chemicals Research Institute, Bhavnagar, where Dr Arup Ghosh is Sr. Principal Scientist and Dr Kanti Bhooshan Pandey is Principal Scientist.*

GENESIS OF CSIR-CSMCRI

- With a coastline of about 3,500 miles, inland sources in Rajasthan and Little Rann of Kutch, and the rock salt mines in Mandi, India has possibilities of attaining a high position in salt production in the world. Apart from being an indispensable item of food, salt is an important raw material for the manufacture of several heavy chemicals, eg. soda ash, caustic soda and chlorine. Besides, salt is used in food processing industries, such as fish curing, meat packing, dairy products and fruit and vegetable canning.
- India had been an importer of salt for a long time as her own production was not sufficient to meet the demand. The position deteriorated further after the Partition, when the extensive rock salt deposits in the Punjab and the marine salt works in Sindh went to Pakistan. Soon after Independence, India was faced with acute shortage of edible salt. The Government set up a committee under the chairmanship of HM Patel, who was then the Cabinet Secretary, to report on measures for overcoming the shortage. The committee submitted several short term proposals and also recommended that a Salt Expert Committee should be appointed to investigate various aspects of the problem.
- The need for salt research was recognized by the Council of Scientific & Industrial Research (CSIR), New Delhi, as early as 1940, when, at the instance of Dr Shanti Swarup Bhatnagar, a Salt Research Committee was established to formulate a programme on the production and utilization of salt.
- In April 1948, the Government of India constituted a Salt Expert Committee under the chairmanship of PA Narielwala to advise on measures necessary to place the Indian salt industry on a sound footing.
- In September 1951, CC Desai, the then Secretary of the Ministry of Works, Production and Supply, proposed that a Central Salt Research Institute be established under the aegis of CSIR for carrying out research on marine salt, and salt from inland lakes and sub-soil brine.
It was suggested that the Institute be located at some centre in Saurashtra; the Ministry of Works, Production and Supply would support any proposal for a grant from the Salt Development Cess for setting up the Institute.
- Meanwhile the Government of Saurashtra made a generous offer to place any of their buildings in Saurashtra at the disposal of the CSIR for housing the institute. PN Kathju, the planning officer of the proposed institute, carried out a preliminary survey of possible sites, both in the north coast and south coast of Saurashtra, for the location of the institute. Bhavnagar, which being a flourishing centre of higher education in Saurashtra, was considered to be suitable for locating the institute. The Saurashtra Government offered to place at the disposal of the CSIR a magnificent building, 'Raj Hotel', for housing the institute, two bungalows and 125 acres of land for the Experimental Salt Farm (ESF). The CSIR thus decided to set up the institute at Bhavnagar.
- Thus Central Salt Research Institute (now known as Central Salt & Marine Chemicals Research Institute) was inaugurated by Pandit Jawaharlal Nehru, the first Prime Minister of India, on 10 April 1954.

SHANTI SWARUP BHATNAGAR PRIZE 2022 / PROF VIMAL MISHRA

Measuring Depletion of Water Resources

Prof Vimal Mishra has quantified the relative contributions of climate change and human activity to the depletion of water resources

■ **Science India Bureau**

Image Courtesy: Pixabay

Prof Vimal Mishra of IIT Gandhinagar has won the 2022 Shanti Swarup Bhatnagar prize in the category of Earth, Atmosphere, Ocean and Planetary Sciences

Vimal Mishra, a professor of civil engineering at the Indian Institute of Technology Gandhinagar (IITGN), has been bestowed with the prestigious Shanti Swarup Bhatnagar Prize 2022 in the category of the Earth, Atmosphere, Ocean and Planetary Sciences for his pioneering work on the depleting ground water resources in India.

Prof Mishra is the sole recipient of the most prestigious science award of the country in this category. The prize, given by the Council of Scientific & Industrial Research (CSIR), has honoured Prof Mishra's exceptional work that investigates the effects of both natural and man-made factors on India's water resources and hydrologic extremes.

Prof Mishra completed his BTech from CSA University, Kanpur, in 2003, following up with an MTech from IIT Kharagpur in 2005. He obtained his PhD from Purdue University in the United States in 2010. He joined IITGN in 2012. Surface water hydrology, large-scale hydrologic modelling, global food and water security, climate variability and change, and water resources management are the main areas of Prof Mishra's study.

The IITGN lab of Prof Mishra has made a substantial contribution to the development of real-time monitoring and prediction systems for floods and droughts in India. "Every research scientist's dream is to receive the Shanti Swarup Bhatnagar Prize," Prof Mishra said in an interview with PIB. "Right now, I feel incredibly honoured and humbled. It has also increased our desire to study and comprehend the effects of climate change and work toward developing mitigation plans. I am grateful that my work has been recognised by CSIR and the award selection committee. I would also like to take this opportunity to express my gratitude to my wonderful family, students, mentors, co-workers, and colleagues for their ongoing support and encouragement," he added.

Climate change has resulted in significant changes in the water cycle. Furthermore, the availability and demand for water in India have been significantly impacted by climate change and human activity. The relative impact of reservoir storage and irrigation on water availability, as well as climate change, has not yet been measured. According to Prof Mishra's research, pumping groundwater for irrigation in north India has caused a rapid decline in groundwater, even though climate change has affected rainfall characteristics and reduced groundwater recharge. In light of global warming, he has also suggested actions for north India's groundwater sustainability.

In order to determine the relative contributions of climate change and human activity to water resources and hydrological extremes, Prof Mishra has created an integrated framework that integrates hydrological modelling with in-situ and satellite-based observations. It incorporates groundwater pumping and irrigation, climate projections, and state-of-the-art hydrological model(s) to represent human interventions. Prof Mishra's team showed that human activity too has contributed to the decline in groundwater in north India.

Prof Mishra demonstrated through the modelling experiments that the primary cause of the massive groundwater decline in north India is excessive groundwater withdrawal for irrigation from deep aquifers. An important part of managing water resources is the monitoring and forecasting of hydrological conditions, such as rainfall and soil moisture. As a result, his group created a framework for hydrological monitoring India in almost real time.

In addition to quantifying the effects of climate change and human activity on water resources and hydrological extremes, the water and climate lab at IITGN has worked with other agencies to develop an operational monitoring and forecasting system.

Quiz: Dr Subhash Mukhopadhyay

1. Dr Subhash Mukhopadhyay, an Indian scientist born on January 16, 1931, is renowned for which landmark of Indian science?
A. He created India's first baby using in-vitro fertilization
B. He created the world's second baby using in-vitro fertilization
C. Both A & B
D. Only A

2. Born in Hazaribagh in present-day Jharkhand, Dr Mukhopadhyay completed his MBBS in 1955 from:
A. Calcutta National Medical College
B. Rajabazar Science College, Calcutta
C. University of Edinburgh
D. University of Cambridge

3. A critically acclaimed Hindi feature film was inspired by his life. What was its title?
A. Ek Doctor Ki Gazab Kahani
B. Ek Doctor Ki Maut
C. Ek Doctor
D. None of the above

4. Dr Mukhopadhyay faced persecution and apathy from the government in his career because of which…
A. He left India to work abroad
B. He gave up his medical practice
C. He committed suicide
D. None of the above

5. The baby he created using in-vitro fertilization was born on October 3, 1978, in Calcutta. Today, she is known as Kanupriya Agarwal. What was she named when she was born?
A. Uma
B. Parvati
C. Kali
D. Durga

6. Dr Mukhopadhyay's work went unheralded and it was another doctor who was credited as the creator of India's first 'test tube' baby until 1997. Who was the doctor?
A. Ashwini Kumar
B. Komal Pradhan
C. TC Anand Kumar
D. A & C

7. Recognition for Dr Mukhopadhyay came long after his death, in 1997, at the initiative of which doctor?
A. TC Anand Kumar
B. Komal Pradhan
C. Ashwini Kumar
D. A & C

8. Dr Mukhopadhyay earned two PhDs, one in Reproductive Physiology and next in Reproductive Endocrinology. Name the universities in that order.
A. University of Calcutta, University of Edinburgh
B. University of Edinburgh, University of Cambridge
C. University of Cambridge, Harvard University
D. University of Calcutta, Stanford University

9. Dr Mukhopadhyay's landmark became second in the world by a margin of only 70 days. The world's first 'test tube' baby, Louise Joy Brown, was born on July 25, 1978, in…
A. New York
B. Manchester
C. Chicago
D. London

10. This year in February, a private Indian University opened a centre for stem cell biology and regenerative medicine named after Dr Subhash Mukhopadhyay. Name it.
A. Amity University, Noida
B. Ashoka University, Sonipat
C. SRM University, Chennai
D. Adamas University, Kolkata

Dr TC Anand Kumar: An Example of Generosity in Science

■ Dr TC Anand Kumar was credited with the creation of India's first baby through in-vitro fertilization till he discovered Dr Subhash Mukhopadhyay's earlier work during a conference in Calcutta in February 1997. He published an article titled, 'Architect of India's first test tube baby: Dr Subhas Mukherjee', through which he established Dr Mukhopadhyay's pioneering work, leading to Indian Council of Medical Research officially acknowledging Dr Subhash Mukhopadhyay as the creator of first Indian baby through in-vitro fertilization.

■ The baby created by Dr Kumar through in-vitro fertilization was born in Bombay on 6 August 1986 through a caesarian section and was named Harsha Chawda.

■ Dr Tiruchirapalli Chelvaraj Anand Kumar was born in Tamil Nadu on 18 January 1936.

■ He earned his doctoral degree from the University of Jodhpur and did his post-doctoral research in the UK, returning to India in 1969.

■ He worked at the All India Institute of Medical Sciences (AIIMS), New Delhi, from 1969-82.

■ He was awarded the prestigious Shanti Swarup Bhatnagar Prize in 1977 for his contributions in the field of neuroendocrinology of primate reproduction.

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

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I. Bhooshana Rao
(6 January 1914 - 3 May 1976)

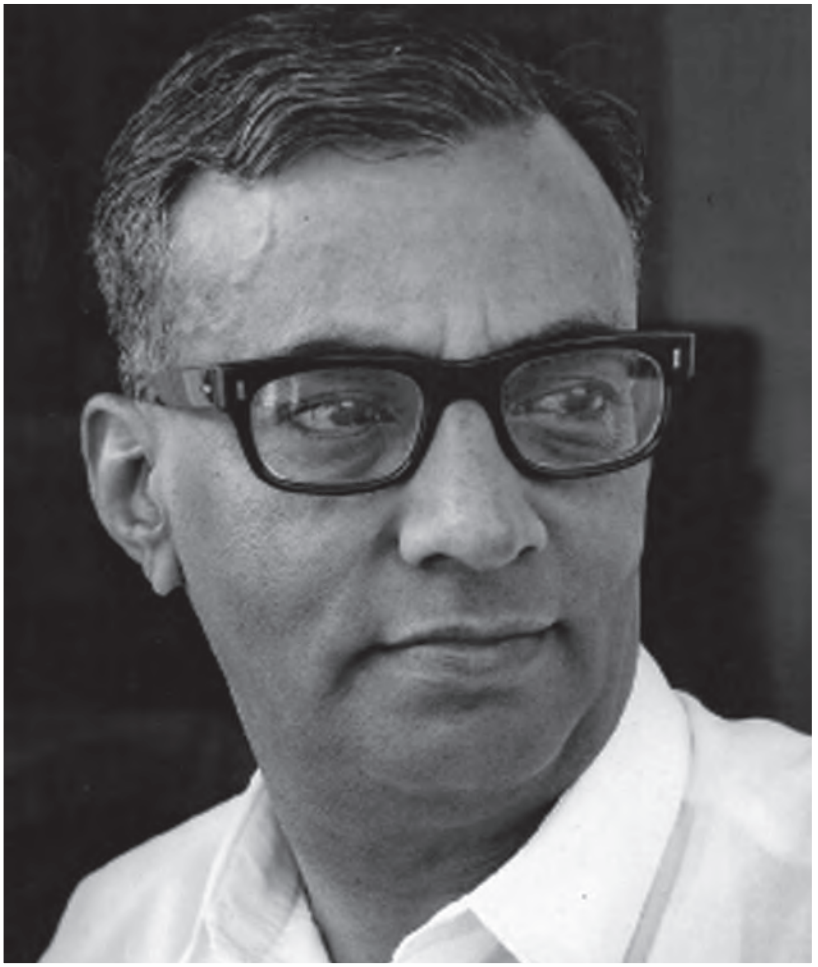

Image Courtesy: Wikimedia Commons

Born in Dornakal in present-day Telangana, Idupuganti Bhooshana Rao was a leading figure in forensic medicine in India. He was the founding president of the Indian Academy of Forensic Medicine, established in 1972 in Panaji.

Celebrating Science This Month

JANUARY 1
Satyendra Nath Bose, best known for his work on quantum mechanics in the early 1920s was born in 1894. He collaborated with Albert Einstein in developing the foundation for Bose-Einstein statistics and the theory of the Bose-Einstein condensate.

Shanti Swarup Bhatnagar, also known as the father of research laboratories, and the first director general of the CSIR, died in 1955. He was a colloid chemist, academic and scientific administrator. He also served as the first chairman of the University Grants Commission (UGC).

Subramanian Kalyanaraman, an Indian neurosurgeon, and a former head of the Department of Neurosurgery at Apollo Hospitals, Chennai, was born in 1934. He was known for his pioneering techniques in stereotactic surgery.

JANUARY 2
Deb Shankar Ray, known for his researches on non-linear dynamics and theoretical spectroscopy, was born in 1954.

JANUARY 3
Bhabha Atomic Research Centre (BARC) was established in 1954. BARC was first instituted as the Atomic Energy Establishment, Trombay (AEET), with Homi Jehangir Bhabha, who conceived India's nuclear programme, as its first director.

JANUARY 5
GSAT-14, the twenty-third geostationary communication satellite of India, was launched in 2014 by GSLV-D5 from SDSC, SHAR, Sriharikota.

JANUARY 6
The founder-president of the Indian Academy of Forensic Medicine, Idupuganti Bhooshana Rao, was born in 1914. He was a leading figure in forensic medicine in India.

JANUARY 7
The Indian National Science Academy (INSA), earlier called the National Institute of Sciences of India, was founded in 1935 in Calcutta. It was shifted to New Delhi in 1951 and got its present name in 1970.

JANUARY 8
Mahatma Gandhi Antarrashtriya Hindi Vishwavidyalaya was established in 1997. It is a central university located in Wardha, Maharashtra.

JANUARY 9
Har Gobind Khorana, Indian-American biochemist and Nobel Prize winner, was born in 1922. He shared the 1968 Nobel Prize for Physiology or Medicine with Marshell W Nierenberg and Robert W Holley.

JANUARY 10
Haffkine Institute in Mumbai, named after Dr Waldemar Mordecai Haffkine, who invented the plague vaccine, was established in 1899.

Babasaheb Bhimrao Ambedkar University, located in Lucknow, was founded in 1996.

JANUARY 12
National Youth Day is celebrated every year to commemorate the birth anniversary of Swami Viyekananda, the great scientific visionary, who was born in 1863. The establishment of the Indian Institute of Sciences in Bengaluru was a result of the interaction of Swamiji with industrialist Jamsetji Tata.

Yellapragada Subbarow, pioneering Indian biochemist was born in 1895. He discovered the function of adenosine triphosphate (ATP) as an energy source in the cell, developed methotrexate for the treatment of cancer and led the department at Lederle laboratories, where Benjamin Minge Duggar discovered chlortetracycline (Aureomycin) in 1945.

JANUARY 13
Rakesh Sharma, the first Indian to travel to space, in a Soviet rocket on 2 April 1984, was born in 1949.

JANUARY 16
Subhash Mukhopadhyay, Indian scientist and physician who created the world's second and India's first child using in-vitro fertilisation, was born in 1931.

JANUARY 17
GSAT-30 was successfully launched into a Geosynchronous Transfer Orbit (GTO) in 2020 from Kourou launch base, French Guiana, by Ariane-5 VA-251.

JANUARY 20
The fifth navigation satellite of the seven satellites constituting the IRNSS space segment IRNSS-1E, was launched from Satish Dhawan Space Centre.

Hindoo College was founded 204 years ago, in 1817. It is now known as Presidency University, Kolkata.

JANUARY 24
The University of Calcutta was established in 1857. It was one of the first multidisciplinary and Western-style institutions in Asia.

Homi Jehangir Bhabha, Indian nuclear physicist, also known as the father of the Indian nuclear programme, died in 1966. He was the founding director of Bhabha Atomic Research Center (BARC).

CSIR-INSTITUTE OF MINERALS AND MATERIALS TECHNOLOGY

Council of Scientific and Industrial Research
Bhubaneswar 751013, INDIA

CORE AREA COMPETENCY

- Material characterization
- Mineral beneficiation, pelletisation and agglomeration
- Extraction of metals from ores, sludge and scraps
- Plasma processing of materials
- Nanomaterials, bio materials and energy materials
- Coatings, thin films, alloys, composites
- Green technology for industrial waste management
- Drinking water filtration and wastewater recycling
- Environmental impact assessment
- CFD/DEM modelling and simulation

Constructed wetland for waste water treatment

XPS

Particle Size Analyzer

High Concentration Slurry Transportation

INDUSTRY INTERFACE

- Technology development for mineral, material, metallurgical and chemical industries
- Contract research and consultancy for process optimization
- TEFR and Basic engineering packages in core area
- Testing of water quality and components in ores, rocks, soils, slags, and processed products
- Skill development

CNC Turning & Milling Machines

FACILITIES

- Mineral processing pilot plant
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- Coal characterization
- Processing of natural gemstones for value addition
- State-of-the art analytical equipments for characterization of ores, minerals & materials
- Commercial scale production facility for fly ash and red mud building materials
- Mechanical workshop for design and fabrication
- Biomass operated cook stoves and testing lab
- Technology validation

Fly Ash & Red Mud Bricks

EPMA

XRD

Plasma Spray Coating

Column Flotation Unit

Hydrogen Plasma Reactor

TCM

X-ray Micro CT

Microwave Plasma Reactor

Scanning Electron Microscope

CONTACT US

Director, CSIR-Institute of Minerals & Materials Technology
Bhubaneswar – 751013
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