National Conclave



" Lab To Society: Science Communication For Shaping Viksit Bharat @ 2047 "

Organized by

ACADEMY FOR SCIENCE, TECHNOLOGY AND COMMUNICATION

Jointly with

EENADU GROUP

in Association with

National Academy of Sciences, India, (NASI) - Telangana Chapter

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National Conclave

"Lab To Society: Science Communication For Shaping Viksit Bharat @ 2047"

8th January, 2026 @ Hyderabad



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Academia Meets Innovation: Be a Part of ASTC"

The Academy for Science, Technology and Communication (ASTC) serves as a unique platform for the academic community to engage in meaningful discussions on scientific and technological advancements.

ASTC welcomes professors, scientists, technologists, and medical professionals from diverse disciplines who are committed to science propagation and have made notable contributions to research and development. Members gain access to academic programs and knowledge-sharing opportunities through various membership categories: Life Member - Annual Member - NRI Member and Institutional Member (for organizations)In addition, ASTC Honorary Fellowships are conferred to recognize outstanding contributions in various fields of science and technology.

To further strengthen ASTC's publication initiatives, a series of concise booklets titled "ASTC COMMUNICATIONS" is being developed. These will cover a range of contemporary scientific topics to disseminate knowledge to a wider audience.

We believe your association will significantly enhance our academic network, foster academia - industry linkages, and promote active engagement within the scientific community. We also invite suggestions for new initiatives and welcome your feedback on ASTC's current activities and future plans.

"Join the Circle of Science: Engage, Inspire, Innovate with ASTC"

For any inquiries, please contact
the Secretary, ASTC, at: astc.academy@gmail.com



Sri M. Venkaiah Naidu

1, Tyagraja Marg,
New Delhi, 110011

Date: 28.12.2025

Message

I would like to record my appreciation of this initiative of the Academy for Science Technology and Communication and the Eenadu Group in organizing the National Conclave on "Lab to Society: Role of Science Communication in Building Viksit Bharat by 2047." The sustained efforts and the dedication of the ASTC and the Eenadu Group to advancing scientific awareness and fostering a scientifically informed society are truly commendable. The Eenadu Group has, over the past five decades, scripted history with its pathbreaking role in building an institution synonymous with people-centric journalism. Its science outreach complements this role perfectly and therefore, the joint efforts of the ASTC and the Eenadu Group to popularize science deserve praise.

Science and technology form the bedrock of progress in the nation's journey toward Viksit Bharat by 2047. Translating lab advancements into societal gains hinges on effective communication.

Schools can be game changers in this journey. They play a transformative role in nurturing scientific temper and curiosity. They should take everyday applications of science and make them relatable and engaging for students.

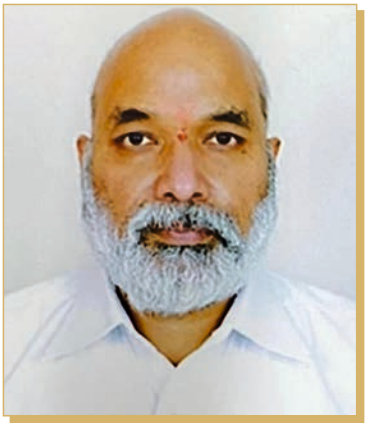
The fact remains that many schools lack proper labs which continues to be a matter of concern. I urge corporates to channel CSR funds into equipping labs, especially in needy and underserved areas. The government could, on its part, establish centralized, state-of-the-art facilities serving school clusters for hands-on learning.

This conclave offers scientists, communicators, educators, and policymakers a vital platform to strengthen these efforts. My best wishes for the success of the Conclave. I earnestly hope that its outcomes ignite a true people's science movement.

Naidu.

(M. Venkaiah Naidu)

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Sri CH. Kiron

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Message

Let us work together towards effective science communication

Greetings to the organisers and participants of the national conclave on "Lab to Society: Role of Science Communication in Building Viksit Bharat @ 2047". The theme of the conclave reminded me the words of a popular American psychologist, who said "Nothing in science has any value to society if it is not communicated". It is indeed an irony that though our daily lives are entirely dependent on science and technology there are very few who are aware of the developments in the field of either science or technology. This situation calls for bridging the communication gap between scientists and the society.

The benefits of effective science communication were witnessed during the Covid time. The pandemic came under control in our country because of the effective communication about the scientific essentiality of following good pandemic habits like wearing masks, washing hands, maintaining distance, taking healthy diet to fight the disease and the need to get vaccinated.

Neil Armstrong's historic moon landing on July 20, 1969, was broadcast live to an estimated 650 million people worldwide. This extensive media coverage stands out as the best example of the positive impact of the effectiveness of science communication on the society. It successfully inspired a generation of children, leading to a significant surge in interest and participation in STEM subjects. We are all currently benefiting from the resultant wave of innovation spurred by that engagement.

Fostering scientific temperament is essential for attaining the lofty goal of achieving Viksit Bharat by the year 2047. Language is a major barrier for effective science communication. If the fruits of the progress in science are to reach the last man, science communication in the mother tongue should be promoted in a big way. I hope this conclave will find ways and means to promote science in regional languages. In an age of social media, clear, reliable science communication help counter myths, superstitions and misinformation, the evils that hinder development.

I hope this conclave will come out with ideas and suggestions to achieve its objectives.

With best wishes.

Sincerely

CH. KIRON
Chairman and Managing Director
Ramoji Group

Regd. Office: Ushodaya Enterprises Pvt. Ltd., 3rd Floor, Corporate Building, Ramoji Film City, Anajpur Village, R.R. Dist, Telangana State - 501 512. India. CIN No. Ü40102TG1973PTC001763, Website: www.eenadu.net



Sri M. Nageshwar Rao
Editor

Message

The mankind's civilizational progress is undoubtedly founded on science as scientific discoveries and technological growth has been driving advancements in every sphere of human life. For the progress to be inclusive and sustainable, there must be a seamless exchange of knowledge between the scientific community and the general public. A collaborative framework has to be established between the media and the scientific community for future development, centred on the enhancement of science literacy.

The promotion of scientific temperament, defined by the spirit of inquiry, logic, and evidence-based reasoning, is the cornerstone of social progress. ln a landscape often clouded by misinformation, the media serves as a vital gatekeeper. The press carries a multifaceted responsibility towards...

- A ctively dismantling superstitions and regressive beliefs that impede intellectual and social evolution.
- T ranslating specialised research into accessible discourse, ensuring that scientific knowledge is not confined to laboratories.
- R igorously fact-checking claims to prevent the proliferation of pseudo-science and anti-inteltectual rhetoric.

A Case Study in Commitment

Eenadu Telugu daily has emerged as a benchmark for science communication by disseminating the developments taking place in the field of science and technology. Right from its inception in 1974, Eenadu has been demonstrating its unwavering commitment to improving scientific awareness among the public. ln accordance with it's founder Chief Editor Sri Ramoji Rao, Eenadu always considered that a progress oriented society requires a foundation of rational thought. Accordingly it consistently dedicated significant editorial space to content that promoted scientific awareness among its readers and kept them informed about the latest scientific developments.

Pioneering initiatives such as the "science-Sense," "Jnananetram," "RaiteRaju," and "Sukheebhava" columns were instrumental in awakening science consciousness among its readers. By prioritising science literacy, Eenadu has successfully bridged the gap between the laboratory and the common reader. lt has successfully proved that language is no barrier to the dissemination of ideas related to science and technology.

Practical Applications: Agriculture and Public Health

Science awareness contributes to the national good when it helps support the economy and contributes to human well-being. Eenadu has been instrumental in communicating scientific knowledge that contributes to...

- Agrarian Modernisation: Through its columns like Jai Kisaan and Annadaata, Eenadu group has been helping the farmers to transform from traditional, sub-optimal practices to high yielding and remunerative precision agriculture Thus it has been promoting science-driven methodologies that are essential for food security and economic resilience.
- Public Health and Nutrition: Eenadu has been a primary source for disseminating scientifically backed nutritional information and protocols for the prevention of diseases.

Resilience Through Technology

- As a media trusted by its readers Eenadu has been able to communicate science based early warnings about cyclones, floods, and seismic activity, derived from rigorous scientific data. Thus it has been acting as an effective tool for mitigation of loss during natural calamities and also help prevent loss of human life.
- A Call to Action for the Scientific Community
- We call upon members of the scientific community to:
- Champion Science communication: Do not remain within academic silos. Proactively collaborate with media outlets to share findings in language that resonates with the public, ensuring that science literacy translates into actionable knowledge.
- Mentor the Youth: Actively participate in programmes that ignite curiosity and foster a passion for inquiry among children, ensuring a robust pipeline of future innovators.
- Advocate Evidence-Based Policy: Use scientific expertise to address social and agricultural challenges, ensuring that policy decisions are rooted in empirical data rather than political expediency or outdated traditions.
- The synergy between scientific community and media is a primary engine of social progress. Through transparent, simplified, and proactive communication, we can build a society defined by enlightenment, health, and shared prosperity.
- Wishing the Nationa! Conclave on Science Communication a grand success...
- Warm regards,



M. Nageswara Rao
Editor, Eenadu



Dr. Soumya Swaminathan

GUEST OF HONOR

Dr. Soumya Swaminathan is a pediatrician and global expert in tuberculosis and HIV research. She was the first Chief Scientist of the World Health Organisation (WHO). Previously, she was the Director General of the Indian Council of Medical Research (ICMR), Ministry of Health and Family Welfare, Government of India (2015-2017). Since February 2023, she has been the Chair of M. S. Swaminathan Research Foundation (MSSRF). She is also the Principal Advisor to National Tuberculosis Elimination Programme (NTEP), Ministry of Health and Family Welfare, Government of India.

With over 40 years of experience in clinical care and research, Dr. Swaminathan has dedicated her career to translating vital research into impactful health programs. As the former Secretary to the Government of India for Health Research, she has prioritised integrating science into health policy-making, enhancing research capabilities in Indian medical institutions, and fostering global partnerships in public health sciences.

Dr. Swaminathan's academic career spans India, the UK, and the US. She has authored over 480 peer-reviewed publications and book chapters. She is a Fellow of the US National Academy of Medicine, the Academy of Medical Sciences (UK) and is an elected Fellow of India's three premier science academies: the National Academy of Sciences (India), Indian National Science Academy, and Indian Academy of Sciences. She holds honorary doctorates from prestigious institutions including the Karolinska Institute, EPFL Lausanne, and the McGill University, London. She currently co-chairs a global commission "Our Common Air" and serves on the Kofi Annan Commission on Food Security. She holds adjunct professorships at Karolinska University (Sweden) and Tufts University (US).

Currently, Dr. Swaminathan serves on the boards of Alliance Bioversity, Population Foundation of India, Institute for Global Environmental Strategies (IGES), Women Lift Health, among others. She is a member of the Governing Council of the Tamil Nadu Climate Change Mission, member of One Health and Climate Change Strategic Committee, Government of Tamil Nadu and Chairs the Scientific Advisory Board of the Indian Council of Medical Research (ICMR).

During her tenure as WHO's first Chief Scientist, Dr. Swaminathan established a Science Division focusing on research, quality assurance of norms and standards, and digital health. She played a pivotal role in coordinating global scientific efforts and was instrumental in setting up Covax to ensure equitable vaccine distribution to low and middle-income countries during the COVID-19 pandemic.

PROGRAMME

8:30 AM – Registration

9:30 AM – Inaugural Session

Arrival of the Chief Guest & Dignitaries, Presentation of Bouquets

Lighting of the Lamp & Prayer

9:35 AM – Welcome: Sri C. L. Narasimha Rao, Secretary, ASTC, Hyderabad

9:40 AM – About the Conclave: Dr. R. B. N. Prasad, Hony. President, ASTC

9:45 AM – Messages by the Guests of Honour

- Dr. Pavuluri Subba Rao, CMD, Ananth Technologies Ltd., Hyderabad
- Sri. M. Nageswara Rao, Editor, Eenadu, Hyderabad
- Dr. D. Srinivasa Reddy, Director, CSIR-Indian Institute of Chemical Technology, Hyderabad

10:05 AM – Presidential Remarks: **Dr. Ch. Mohan Rao**, Chairman, SAC–ASTC & Chairman, NASI – Telangana Chapter

10:10 AM – **Address by the Guest of Honour**

Dr. Soumya Swaminathan, Chair, MSSRF; Principal Advisor, NTEP, Former DG, ICMR and Former Chief Scientist, WHO

Felicitation to Dr. Soumya Swaminathan by the Hon'ble Chief Guest

Release of "ASTC–COMMUNICATIONS" - "Gas Hydrates: A Potential, Clean Energy Source for India" - "Cancer, Screening and Prevention" & Conclave Souvenir by the Hon'ble Chief Guest

Felicitation to the Authors

10:35 AM – Felicitations by the Hon'ble Chief Guest to

"Eminent Scientists & Distinguished Science Communicators"

- **Dr. D. Balasubramanian**, Former Director of Research, LVPEI & Former Director, CCMB
- **Dr. B. G. Sidharth**, Founder DG, B.M.Birla Science Centre
- **Sri Pallava Bagla**, Senior Science Editor, NDTV

Felicitations to Recipients of Govt. of India Highest Award **'Vigyan Shri'**

- **Dr. K. Thangaraj**, Former Director, CDFD, Hyderabad
- **Dr. S. Venkata Mohan,** Director, CSIR-NEERI, Nagpur

10:50 AM – Inaugural Address by the Chief Guest

Shri Muppavarapu Venkaiah Naidu, Hon'ble 13th Vice President of India

Felicitations to the Chief Guest by ASTC & Eenadu Group

Presentation of Mementoes to the Dignitaries and presentation of Certificates to New Fellows - 2025

Vote of Thanks - Sri K. Suresh, Chief Sub-Editor, Eenadu

Jana Gana Mana

High Tea

11.30 AM - Session I - Advancements in Space & Defence Sectors: Lab to Society

Chairman

Dr. D. N. Reddy, Former Chairman, RAC-DRDO & Fromer VC, JNTU-Hyderabad

Keynote Lectures

1. Space and Planetary Explorations: Chandrayan 3 and Beyond

   Sri J. A. Kamalakar, Former Director, ISRO and Prof. Satish Dhawan Scientist, ISRO Satellite Centre, Bangalore

2. India's Major Achievements in Space Sciences

   Dr. V. Seshagiri Rao, Former Distinguished Scientist & Associate Director, ISRO and Former Satish Dhawan Professor, ISRO

3. Defence Technologies for Societal Benefit

   Dr. V. Bhujanga Rao, Chairman, KIMS Foundation & Research Centre, Former Distinguished Scientist & Director General, DRDO and Former ISRO Chair Professor

4. Materials Research for National Strategic Programs: Marching towards Viksit Bharat 2047

   Dr. S.V.S. Narayana Murty, Chairman and Managing Director, MIDHANI, Hyderabad

1.30 PM - Lunch

2.00 PM - Session II - The Role of Science Communication in Disseminating Scientific Achievements to the General Public

Chairman

Dr. B. Sesikeran, Former Director, ICMR-National Institute of Nutrition, Hyderabad

Keynote Lectures

1. Bridging the Communication Gap: How to Make S&T a Shared National Dream

   Shri Pallava Bagla, Senior Science Editor, NDTV, New Delhi

2. Mainstreaming Science Journalism: A View from the Academy

   Dr. Usha Raman, Former Professor, Dept. of Communication, University of Hyderabad

3.00 PM - Session III - Advancements in Health and Nutrition: Lab to Society

Chairman

Dr. Ahmed Kamal, Prime Minister Professor, Osmania University, Former Outstanding Scientist, CSIR-IICT, Hyderabad

Keynote Lectures

1. Preparing for the Deluge of Non-communicable Diseases

   Dr. D. Raghunadharao, Professor of Medical Oncology, MNJ Cancer Hospital, Hyderabad

2. Nutrition Policies and Programs in India - A Constant Communication Dilemma Between Facts and Fiction

   Dr. Subba Rao M Gavaravarapu, Scientist-G & Head-NICHE, ICMR-National Institute of Nutrition, Hyderabad

04.15 PM - Tea Break

4.30 PM - **Session IV - Panel Discussion on "Discovery to Dialogue: Reimagining Science Communication for a Sustainable Future"**

Chairman

Dr. Ch. Mohan Rao, Chairman, Scientific Advisory Council - ASTC, Former Director, CSIR-CCMB, Hyderabad & Chairman, NASI - Telangana Chapter

Panellists

Dr. B. Venkataraman, Former Director, IGCAR & DAE Homi Sethna Chair

Dr. D. Shailaja, Distinguished Scientist, CSIR HQ, New Delhi

Sri M. Somasekhar, Senior Journalist, Business Line, Hyderabad

Prof. Vijaya Khadar, Former Professor, ANGRAU, Hyderabad

Smt. N. Aparna Rao, ARCI, Hyderabad

Prof. Kirtimaan Syal, Associate Professor, Dept. of Biological Sciences, BITS-Hyderabad

Sri Naresh Nunna, Managing Editor, Neo-Science Hub, Hyderabad.

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former VC, JNTU-Hyderabad

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Former Director
National Institute of Nutrition, Hyderabad

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Hyderabad

G. Harshitha Reddy
Research Scholar, CSIR-NGRI
Hyderabad

Conclave at a Glance

Dr R B N Prasad

Hony. President, ASTC & Former Chief Scientist & Head, Centre for Lipid Research
CSIR-Indian Institute of Chemical Technology

ASTC's Vision & Mission

The Academy for Science, Technology and Communication (ASTC) is dedicated to advancing science, technology, and education by fostering meaningful engagement among academic, scientific, and societal stakeholders. Through lectures, seminars, workshops, symposia, panel discussions, and its flagship publication ASTC Communications, the Academy disseminates scientific knowledge and promotes interdisciplinary collaboration. ASTC's initiatives are designed to nurture scientific temper, curiosity, and creativity across students, educators, and the wider public, while encouraging excellence and innovation.

Science Communication Conclave

Science communication plays a pivotal role in translating research outcomes into tangible societal benefits. Recognizing this imperative, the National Conclave seeks to strengthen science communication by bringing together scientists, educators, policymakers, media professionals, and the public on a common platform. By facilitating dialogue across disciplines and sectors, the conclave underscores the role of effective communication in fostering innovation, informed decision-making, and inclusive national development.

This conclave is distinguished by the collaborative partnership between ASTC and the Eenadu Group, a leading media organization, marking their maiden joint initiative in the domain of science communication. Together, these organizations aim to connect key stakeholders, build trust in science, and promote inclusivity and innovation, aligned with the national vision of a self-reliant and informed India by 2047. Special efforts have been undertaken to engage science journalists and science teachers, empowering them to communicate scientific concepts with clarity, accuracy, and societal relevance.

The conclave's key objectives include strengthening science communication for national progress; integrating science with policy and society; leveraging digital platforms, artificial intelligence, and emerging technologies; simplifying complex scientific ideas; supporting educators; engaging communities; promoting communication in local languages; fostering global collaborations; and equipping young minds with future-ready skills. By positioning science communication as both dissemination and dialogue, the conclave aspires to cultivate a society empowered by shared knowledge and collective understanding.

ASTC gratefully acknowledges the Eenadu Group for its committed partnership and valuable support in advancing the cause of science communication in India.

Inaugural Function

Every major event is inaugurated with a formal opening session graced by distinguished leaders and champions whose contributions resonate with the theme of the conclave. Their inspirational addresses set the tone for meaningful deliberations and engagement throughout the programme. In this spirit, ASTC and the Eenadu Group are honoured to mark this milestone with the gracious presence of Shri M. Venkaiah Naidu garu, Hon'ble 13th Vice President of India, who will attend the Conclave and share his visionary thoughts with the participants.

During his tenure as Vice President of India, Shri Venkaiah Naidu garu consistently championed the cause of science beyond the confines of laboratories by advocating policy reform, strengthening public communication, and supporting scientific institutions. He emphasized the importance of science communication in regional languages, promoted outreach through diverse media platforms and public forums, and underscored the cultivation of scientific temper as a Fundamental Duty. He also proposed the concept of Scientific Social Responsibility (SSR), highlighted the achievements of Indian scientists to inspire the youth, encouraged schools and colleges to celebrate scientific contributions, and strongly advocated making science accessible to all sections of society. He continues to pursue this mission by inspiring young minds and promoting the use of the mother tongue as a medium for science communication.

The Conclave is also privileged to welcome Dr. Soumya Swaminathan—Chair, M. S. Swaminathan Research Foundation; Principal Advisor, National Tuberculosis Elimination Programme (NTEP); former Director General, ICMR; and former Chief Scientist, WHO—as the Guest of Honour. Her message is expected to motivate and energize the delegates. A globally respected scientific communicator, particularly during the COVID-19 pandemic, Dr. Swaminathan played a pivotal role at the WHO in making scientific evidence accessible to the public. She promoted transparent, evidence-based decision-making through "living guidelines," clarified evolving scientific data on variants, vaccines, and treatments, addressed misinformation with clarity, and strengthened stakeholder engagement and digital outreach. As Chair of the M. S. Swaminathan Research Foundation, she continues to advance effective communication in the areas of climate and health, nutrition, food systems, and tribal and rural health.

The inaugural function will be further enhanced by the gracious presence and messages from five distinguished guests, including Dr. P. Appa Rao, Former Vice Chancellor of the University of Hyderabad; Dr. Pavuluri Subba Rao, Chairman and Managing Director of Ananth Technologies Ltd., Hyderabad & President of the AP Space Tech Academy; Sri M. Nageswara Rao, Editor of Eenadu, Hyderabad; Dr. D. Srinivasa Reddy, Director of CSIR-Indian Institute of Chemical Technology, Hyderabad and Dr. Ch. Mohan Rao Chairman, SAC–ASTC, Senior Professor Emeritus BITS-PILANI-Hyderabad and Former Director of CSIR-Centre for Cellular and Molecular Biology, Hyderabad. Each of these esteemed guests are recognized as an expert in their respective fields and are also highly regarded for their significant contributions to science communication.

As part of its tradition, during inaugural function, ASTC is honouring Dr D. Balasubramanian, former Director of Research at LVPEI and former Director of CCMB; Dr B. G. Sidharth, Founder and Director General of B.M. Birla Science Centre; and Sri Pallava Bagla, Senior Science Editor at NDTV, all of whom are eminent scientists and distinguished science communicators. ASTC also extends felicitations to Dr K. Thangaraj, former Director of CDFD, Hyderabad, and Dr S. Venkata Mohan, Director of CSIR-NEERI, Nagpur (who are also MEMBERS OF the SAC-ASTC), who have received the Government of India's highest award, 'Vigyan Shri'.

As part of the Conclave, ASTC published a Souvenir featuring insightful articles on science communication and lecture abstracts that highlight pioneering research, major accomplishments, innovative achievements, and flagship projects from nationally recognized research laboratories. ASTC extends its appreciation to contributors of special articles in areas such as space, defence, health, and nutrition.

Notable experts include Dr. B. Sesikeran, Former Director of ICMR- National Institute of Nutrition (NIN), Hyderabad; Dr. Ahmed Kamal, Prime Minister Professor at Osmania University and Former Outstanding Scientist at CSIR-IICT; Dr. K.R.S. Sambasiva Rao, Vice-Chancellor of Mangalayatan University, Jabalpur; Dr. Kusumita Arora, Director of the Indo German Science & Technology Centre, New Delhi; Dr. Vijayalakshmi Venkatesan, Director-Research at Regenerative Research Pvt Ltd, Hyderabad and Former Scientist G at ICMR-NIN, Hyderabad; Dr. Suresh Itapu, CEO of NutriTech

Consulting Services Pvt Ltd; Dr. R.B.N. Prasad, Former Chief Scientist at CSIR-IICT; and Dr. C.V.S. Kiran, Co-Founder & CEO of Red Balloon Aerospace Private Limited.

Following the inaugural function, the Conclave comprises two thematic sessions on "Advancements in Space, Defence, Health, and Nutrition Sectors: Lab to Society," one session on "The Role of Science Communication in Disseminating Scientific Achievements to the General Public," and a concluding panel discussion titled "Discovery to Dialogue: Reimagining Science Communication for a Sustainable Future."

Session 1

The opening session on Advancements in Space & Defence Sectors: Lab to Society will be chaired by Dr. D. N. Reddy, a highly respected academic leader, mechanical engineer, and science administrator. Dr. Reddy has served as Former Chairman of RAC-DRDO and Former Vice-Chancellor of JNTU Hyderabad.

This session features four lectures. The first will be delivered by Sri J. A. Kamalakar, Former Director, ISRO, and Satish Dhawan Scientist, with over four decades of experience in Indian space science. His talk, "Space and Planetary Explorations: Chandrayaan-3 and Beyond," will outline India's major space milestones, including the Chandrayaan missions and the historic Chandrayaan-3 lunar south pole landing, and will touch upon future initiatives such as Chandrayaan-4 and the Bharatiya Antariksha Station.

Dr. V. Seshagiri Rao, a former Distinguished Scientist and Associate Director at ISRO, as well as a former Satish Dhawan Professor, will deliver the second lecture. With over forty years of experience at ISRO, Dr. Rao is a renowned Indian space scientist. His talk will cover India's major space achievements, such as ISRO's launch vehicles, Chandrayaan and Mangalyaan missions, advanced satellites, and collaborations like NISAR with NASA. India has also developed systems like NavIC and Gaganyaan, which support disaster management, agriculture, telemedicine, education, and security. Vision 2047 sets goals for further progress and global cooperation.

The third lecture of this session will be presented by Dr. V. Bhujanga Rao, Former Distinguished Scientist & Director General at DRDO, and Former ISRO Chair Professor. Dr. Rao is a renowned Indian scientist, technologist, and strategic leader with over forty years of experience in the defence sector. His talk highlights DRDO as India's leading defence R&D agency, which has developed numerous advanced indigenous technologies, such as missile platforms, naval weapons, and electronic warfare systems, and also supports civilian applications and MSMEs through technology transfer, funding, and innovation initiatives.

Dr. S.V.S. Narayana Murty, Chairman & Managing Director of MIDHANI, Hyderabad, will deliver the Session's final lecture entitled "Materials Research for National Strategic Programs: Marching towards Viksit Bharat 2047". He is renowned for his contributions to aerospace materials, ultra-high-strength alloys, failure analysis, and space propulsion systems. Dr. Narayana Murty highlights India's progress in materials research and strategic sectors since independence, stressing the need for indigenous material development and human resources to achieve self-reliance and position India as a global leader in advanced technologies by 2047.

Session 2

The second session on the Role of Science Communication in Disseminating Scientific Achievements to the General Public will be chaired by Dr B Sesikeran, Director of the National Institute of Nutrition, Hyderabad, who is one of India's most respected nutrition scientists, pathologists, and public health experts. The session has two lectures.

The first lecture will be delivered by Shri Pallava Bagla, Senior Science Editor, NDTV, New Delhi. Shri Pallava Bagla is a charismatic Indian science communicator respected for his deep understanding of India's S&T system and will be speaking on . "Bridging the Communication Gap: How to Make S&T a Shared National Dream". The lecture emphasizes the importance of strong science communication in

India's technological progress, calling for institutional support, journalist training, responsible use of social media, and recognition of scientists to better connect innovation with public engagement and advance Atma Nirbhar Bharat.

The second lecture of the session Mainstreaming Science Journalism: A View from the Academy Dr. Usha Raman, Former Professor, Dept. of Communication, University of Hyderabad who is known for her leadership roles in global media research bodies and her contributions to science communication and journalism pedagogy. Dr. Usha Raman highlights that science journalism is essential in media but faces challenges in Indian journalism education due to limited specialized training. She notes that growing interest in science reporting comes mainly from scientific institutions, emphasizing the need for better journalist preparation to communicate scientific developments effectively.

Session 3

The third session of the conclave covers "Advancements in Health and Nutrition: Lab to Society" and Dr. Ahmed Kamal, Prime Minister Professor, Osmania University, Former Outstanding Scientist, CSIR-IICT, Hyderabad will be chairing this session. Dr Kamal is a highly accomplished Indian medicinal chemist known for his contributions to anticancer drug design, medicinal chemistry, and pharmaceutical sciences.

Dr. D. Raghunadharao, Professor of Medical Oncology, MNJ Cancer Hospital, Hyderabad is one of India's distinguished leaders in Medical Oncology, with more than four decades of dedicated service in cancer care clinical research, training, teaching and patient advocacy will be delivering the first lecture of this session on Preparing for the Deluge of Non-communicable. India's rising rates of non-communicable diseases like heart disease, diabetes, respiratory illnesses, and cancer are linked to urbanization and changing lifestyles. Dr Raghunatharao suggests lifestyle modification, early detection, government action, and stronger healthcare systems to address these challenges.

The second lecture of the series will be presented by Dr. Subba Rao M Gavaravarapu, Scientist-G & Head-NICHE, ICMR-National Institute of Nutrition, uniquely blends his social science roots with two decades of expertise in nutrition communication, public policy, and community engagement. His presentation covers "Nutrition Policies and Programs in India- A Constant Communication Dilemma Between Facts and Fiction". India's nutrition policies struggle with a communication gap caused by evolving science and widespread misinformation. Effective policy design needs context-aware, trust-based, and multi-stakeholder communication to connect evidence with public action and Dr Subba Rao covers thee points during his presentation.

Panel Discussion

The concluding session of the conclave will feature a panel discussion entitled "Discovery to Dialogue: Reimagining Science Communication for a Sustainable Future." This session will be chaired by Dr. Ch. Mohan Rao, Senior Professor Emeritus at BITS-Pilani Hyderabad and Former Director of CSIR-CCMB, Hyderabad, who is highly respected for his significant contributions to science communication.

The distinguished panel comprises Dr. B. Venkataraman, Former Director, Indira Gandhi Centre for Atomic Research, Kalpakam; Dr. D. Shailaja, Distinguished Scientist, CSIR HQ, New Delhi; Mr. M. Somasekhar, Senior Journalist, Business Line, Hyderabad; Prof. Vijaya Khadar, Former Professor, ANGRAU, Hyderabad; Ms. N. Aparna Rao, ARCI, Hyderabad; Prof. Kirtimaan Syal, Associate Professor, Department of Biological Sciences, BITS-Hyderabad; and Mr. Naresh Nunna, Managing Editor, Neo Science Hub, Hyderabad. The discussion will address strategies for bridging research and society through science communication, with an emphasis on creative, inclusive, and responsible approaches. Additionally, the panel will explore the impact of effective communication on public trust, awareness, and advancement toward Viksit Bharat @ 2047.



ABSTRACTS
OF
KEYNOTE SPEAKERS



Space and Planetary Explorations: Chandrayan 3 and Beyond

Sri J A Kamalakar

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CHANDRAYAN-3 mission is acclaimed as a resounding Space technology achievement of INDIA space programme. Even advanced countries across the globe are admiring the grand technological success of Indian scientists.

With the vision of Vikram Sarabhai that for the peaceful uses and to bring benefits of space technology for its people India will be second to none, the Indian space research organization works on many areas of space research like earth observation, navigation, Telecommunication, human space flight, launch vehicles, space and planetary exploration, planetary sciences etc. Chandrayan 1 launched in 2008 was the first mission by ISRO for planetary exploration. Before Chandrayan, the maximum orbital altitude achieved was 36000 km for the geo synchronous satellites. Chandrayan was the first attempt to reach 3.8 lakh km and orbit around moon. The spacecraft carried multiple Indian and international payloads for scientific studies. Next Mars orbiter was launched. Both chandrayan1 and MARs orbiter missions were a grand success in the first attempt by ISRO. Presence of water molecules on moon was detected for the first time using moon mineralogy mapper and other instruments. Entire topography of moon was mapped by lunar laser ranging instrument and TMC camera.

As a next step towards moon exploration, the two lander missions Chandrayan 2 and Chandrayan 3 were planned and launched leading to successful landing for the first time near south pole. The guidance algorithms were well supported by the performance of absolute sensors which were designed and realized in-house. Chandrayan 1,2,3 with multiple payloads have provided immense Knowledge about the composition and characteristics of moon.

As a next step towards moon exploration very complex Chandrayan 4, a sample return mission by ISRO and also a collaborative lander mission Chandrayan 5 are in progress. The sample return mission is very complex as it involves not only landing but also involves sample collection, ascent from moon, return to earth atmosphere and reenter and finally land at a preplanned designated site in India. Preliminary Studies are also on for ultimate goal of landing humans on moon.

For successful future missions like Chandrayan 4, Bharatiya Antariksha station docking of two modules in space is essential. For this purpose a space docking experiment SPADEX was planned. Many new docking sensors and algorithms were developed. The project successfully demonstrated docking in axial, radial directions, and undocking. Two more spadex experiments are shortly being designed and planned to simulate the chandrayan4 and BAS equivalent docking conditions to make sure docking will happen without any hurdle in the critical projects.

Bharatiya Antariksha station BAS our own Indian space orbiting lab which will involve multiple launching, dockings and human involvement in space to build the station is another complex mission being built by ISRO with support of multiple public & private agencies .



Shri J A Kamalakar

Shri J A Kamalakar is a distinguished Indian space scientist whose career spans over four decades of pioneering work at the Indian Space Research Organisation (ISRO). He is a visionary engineer, a respected mentor and a lifelong contributor to India's space mission. He completed his B Tech and M Tech degrees from National Institute of Technology (NIT), Calicut and NIT, Warangal. Shri Kamalakar is widely recognized for his contributions to Electro-optics and Electronics Instrumentation.

He held many critical roles in LEOS (Laboratory for Electro-Optical Systems) a unit of ISRO, which is the only laboratory in the entire country for development of Advanced optics and electro optical sensors for supporting the remote sensing and communication satellite programmes and was the Director of the lab until July 2014. Shir Kamalakar co authored multiple technical papers on the design and development of laser transmitters for space applications, including QCW Laser Diode Driver Design

He is instrumental in developing variety of electro optic sensors Infrared earth sensors, Sun sensors, Star sensors for all the Indian satellite projects. His efforts have led to total indigenization of these sensors. He was the Instrument Scientist and designer for the lunar laser altimeter payload for Chandrayan-1 the first Indian mission to moon and also involved in development of Lyman alpha photometer of Mars mission. Shri Kamalakar was re appointed as Prof. Satish Dhawan Scientist at ISRO Satellite Centre (URSC), Bangalore and as chairman of Standing design review committee at the Satellite Centre, he was associated with important ISRO projects Chandrayan 3, space docking experiment, Aditya and other communication and remote sensing projects. Beyond his engineering accomplishments, Kamalakar has played a vital role in India's emerging human spaceflight ecosystem. As part of ISRO's technical training team, he helped train Gp Capt Shubanshu Shukla and three fellow astronauts in satellite avionics prior to their mission to the International Space Station (ISS)—a milestone celebrated by the NITC Alumni Network as a moment of national pride

Shri Kamalakar received several awards like ISRO Merit Award for Electro Optics; International Academy of Astronautics Team Achievement Award for Chandrayan 1; Team excellence award of ISRO for contribution to Chandrayan 1 Payload instruments, development of Space rade Laser source, Lyman Alpha Photometer for MARS mission; C V Raman Performance Excellence Award; Distinguished Alumini Award for Technology innovation excellence NIT Calicut etc.

Other important missions Venus orbiting mission, xposat, Mars lander are also under study. The talk will provide brief information on the critical technologies and challenges faced for successful operations of Chandrayan 3 and challenges and need of multiple technologies required for the new projects Chandrayan 4 & BAS01.



India's Major Achievements in Space Sciences

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India has emerged as a global leader in space sciences through a series of pioneering missions, indigenous innovations, and impactful applications that have transformed both national development and international collaboration. The Indian Space Research Organisation (ISRO), established in 1969, has spearheaded this journey with a vision to harness space technology for societal benefit.

Key Achievements

- **Satellite Launch Capabilities:** India developed indigenous launch vehicles such as the Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV), enabling cost-effective access to space and earning global recognition for reliable launches.
- **Planetary Exploration:** Landmark missions like Chandrayaan-1 (2008) discovered water molecules on the Moon, while Mangalyaan (Mars Orbiter Mission, 2013) made India the first Asian nation to reach Mars orbit and the first globally to do so on its maiden attempt. Adity L1 mission is a unique one for studying Sun.
- **Earth Observation and Communication:** India's constellation of remote sensing satellites provides critical data for agriculture, disaster management, urban planning, and environmental monitoring. Communication satellites have revolutionized telecommunication, broadcasting, and internet services across the country.
- **NISAR:** NISAR (NASA-ISRO Synthetic Aperture Radar) is a landmark joint Earth-observation mission between NASA and ISRO, launched in July 2025, featuring the world's most advanced dual-frequency radar to map Earth's changing surface, ecosystems, ice sheets, and natural hazards like earthquakes and landslides with unprecedented detail every 12 days, providing crucial data for climate science and disaster management globally
- **Navigation Systems:** The Indian Regional Navigation Satellite System (IRNSS), also known as NavIC, offers precise positioning services for both civilian and military applications, enhancing self-reliance in navigation.
- **Human Spaceflight and Future Missions:** The upcoming Gaganyaan mission aims to send Indian astronauts into space, marking a new era in human spaceflight. India is also advancing lunar exploration with Chandrayaan-3 and participating in international collaborations.

India's space research, spearheaded by ISRO, delivers massive societal benefits through enhanced communication, navigation (NavIC), disaster management, resource monitoring (agriculture, water), weather forecasting, telemedicine, and education, driving economic growth, job creation, and improving governance by providing critical data for development across sectors, from national security to everyday services.



Dr. V. Seshagiri Rao

Dr. Seshagiri Rao Vellanki is an Indian scientist and is former Distinguished Scientist and Associate Director of the Satish Dhawan Space Centre (SDSC), Indian Space Research Organisation (ISRO). He worked in ISRO for more than 39 years in various capacities. He also served in ISRO as Prof. Satish Dhawan for three years. He was instrumental in setting up state of the art Real Time Systems and computer networks for flight safety at SDSC SHAR. He also developed data processing software required for displaying flight trajectories. Pulse Coherent Mono-pulse Radars (PCMC) development and commissioning was carried out under his leadership. Dr Rao also developed and implemented various algorithms required for wind profile estimation for weather monitoring. He worked extensively in Mission Simulations and Post flight trajectory estimation and data analytics. He contributed significantly to the Satellite recovery experiment, Chandrayan-1 Mangalyaan and many other missions. ISRO's prestigious Multi Object Tracking Radar (MOTR) was designed, developed and commissioned under his guidance as Project Director. He is responsible for developing and implementing Software for Computerisation of Working Administrative areas for ISRO in all centres.

He received several awards, including the SPACE Gold Medal, ISRO Merit Award, ISRO Performance Excellence Award, Team Excellence Awards (for four times), Lifetime Achievement Award, ASSOCHAM Award, Aerospace Eminence Award and Engineering Seva Ratna Award. He is a life member in number of professional bodies. He published more than 65 research papers and guided Ph D students. He is a well known speaker both at national and international forums to promote Space sciences and Deep Tech. He is also known for working in imparting Quantum Technologies skill sets among academia and students.

Societal Benefits

Disaster Management & Weather: Satellites provide crucial data for cyclone tracking, flood monitoring, and early warnings, saving lives and property.

Agriculture & Environment: Remote sensing helps monitor crop health, soil moisture, land degradation, and water resources for better management.

Navigation & Location Services: NavIC (Indian Regional Navigation Satellite System) offers precise positioning for transportation, surveying, and safety alerts.

Communication & Connectivity: INSAT/GSAT satellites enable TV broadcasting, telecommunications, and extend digital services (telemedicine, tele-education) to remote areas.

Resource & Urban Planning: Satellite imagery aids in cartography, urban development, and managing natural resources like forests and mines.

Economic Growth & Jobs: The space program creates employment directly and indirectly, stimulates related industries, and offers a significant return on investment.

Science & Technology Spin-offs: Technologies developed for space, like advanced adhesives, find applications in automotive and other industries, boosting innovation.

EDUSAT: EDUSAT is India's first dedicated educational satellite, providing interactive, satellite-based distance learning for schools, colleges, and remote areas using Ku-band and C-band transponders to deliver digital content and facilitate virtual classrooms, revolutionizing access to quality education across the nation.

eSanjeevini: Indian space telemedicine, spearheaded by ISRO, uses satellite tech to bring super-specialty healthcare to rural India via teleconsultations, education, and disaster relief, connecting remote clinics to big hospitals for expert advice, leveraging platforms like eSanjeevani for broader digital health, and focusing on improving access, training, and specialized care in underserved areas using integrated hardware and software for remote diagnostics.

Bhuvan: Bhuvan is ISRO's (Indian Space Research Organisation) national geoportal, a web-based platform offering satellite data, thematic maps (land, water, disaster), and geospatial tools for public visualization, analysis, and data download, promoting India's National Geospatial Policy for development, security, and research, accessible in multiple Indian languages. Developed by the National Remote Sensing Centre (NRSC), it acts as a gateway to India's Earth observation resources for governance, planning, and citizen services

National Security: Space assets enhance military communication, surveillance, and border monitoring.

Indian astronaut Shubhanshu Shukla, during the Axiom-4 mission in mid-2025, successfully conducted seven key ISRO-designed microgravity experiments on the International Space Station (ISS), focusing on biology (Tardigrades, microalgae, muscle cells, seed sprouting) for food/life support, human health (muscle, brain-computer interface), and material science, paving the way for India's human spaceflight program by studying life's adaptation to space for future Moon/Mars missions and Earth-based health/tech solutions.

Experiments Summary

Voyager Tardigrades: Studied the survival, revival, and molecular changes in resilient "water bears" in microgravity, relevant for long-duration space travel.

Myogenesis (Muscle Cells): Investigated muscle stem cell development and the effects of supplements to combat muscle loss in space, with potential for treating aging-related muscle issues on Earth.

Seed Sprouting (Methi/Moong): Tested sprouting of common Indian salad seeds to assess efficient, compact food production for space.

Microalgae & Cyanobacteria: Analyzed these organisms for oxygen production, CO2 absorption, and nutrition, vital for closed-loop life support.

Crop Seeds: Studied growth responses of food crop seeds to spaceflight for space agriculture.

Human-Computer Interaction: Assessed astronauts' interaction with displays in microgravity, possibly using BCI tech for future interfaces.

Astronaut Health: Contributed to monitoring mental health and brain activity in space.

These experiments provided crucial data for India's human spaceflight goals (like Gaganyaan), offering solutions for space food, life support, astronaut health, and even terrestrial applications in medicine and resource management.

India's space future is packed with ambitious missions, focusing on human spaceflight (Gaganyaan), lunar exploration (Chandrayaan-4 sample return), Venus study (VOM), deep-sea exploration (Samudrayaan), building a national space station (Bharatiya Antariksh Station), and Mars exploration (Mangalyaan-2) by 2030, all under ISRO's Vision 2047, aiming for human lunar missions by 2040 and global leadership. Key near-term goals include uncrewed Gaganyaan flights by 2026 and launching the first space station module.

Special Science Missions

Indian Chandrayaan missions (1, 2, 3) have focused on lunar exploration, with key experiments including discovering water molecules (Chandrayaan-1), mapping lunar composition, studying the lunar exosphere, analyzing elemental makeup (Mg, Al, Si, S) via LIBS (Chandrayaan-3), measuring thermal properties (ChaSTE), seismicity (ILSA), and plasma (RAMBHA) on the surface, all contributing to understanding the Moon's geology, potential habitability, and resource potential, particularly around the South Pole.

Aditya-L1 is India's first dedicated solar mission by ISRO, studying the Sun's atmosphere (photosphere, chromosphere, corona) from a unique vantage point at the Sun-Earth Lagrange Point 1 (L1), about 1.5 million km from Earth, providing continuous observation without eclipses to understand solar

phenomena like flares, CMEs, and their impact on space weather, marking India's entry into elite solar observatories. Launched in September 2023, it carries seven payloads, including telescopes for UV imaging and X-ray spectroscopy, capturing unprecedented views and data on solar activities.

XPoSat (X-ray Polarimeter Satellite) is India's first dedicated mission to study X-ray polarization from bright celestial sources like black holes and neutron stars, launched by ISRO on January 1, 2024, on a PSLV rocket, carrying two payloads (POLIX & XSPECT) to provide deeper insights into extreme cosmic phenomena by adding polarization data to spectroscopy and timing. It's the world's second mission of its kind, aiming to enhance understanding of emission processes in space

Upcoming Missions

Gaganyaan (Human Spaceflight): Uncrewed test flights are planned for 2026, leading to India's first human spaceflight, with the goal of crewed lunar missions by 2040.

Chandrayaan-4 (Lunar Sample Return): A dual-launch mission targeting 2027 to land and bring back lunar samples to Earth, building on Chandrayaan-3's success.

Venus Orbiter Mission (VOM): An orbiter to study Venus's atmosphere and surface with high resolution, planned for around 2028.

Bharatiya Antariksh Station (BAS): Developing the first module of India's indigenous space station for microgravity research, with validation missions through 2028.

Mangalyaan-2 (Mars Orbiter/Lander): Aiming to land on Mars, with a potential launch around 2030.

Long-Term Vision (Vision 2047): Establish a national space station (BAS).Achieve human missions to the Moon by 2040.

Become a leader in space exploration, science, and commerce.

ISRO Outreach: Indian space outreach, primarily led by ISRO, involves extensive programs like exhibitions, e-learning, student initiatives (NE-SPARKS), and international collaborations (IAC, World Expo) to foster public awareness, inspire youth in STEM, and build capacity in space tech, extending beyond traditional methods through initiatives like Space on Wheels and training programs for foreign participants. Key players include ISRO, NRSC, and IIST, all focused on democratizing space knowledge and technology application.

Indian Space YUVIKA (YUva VIgyani KAryakram) is ISRO's (Indian Space Research Organisation) annual "Young Scientist Programme," a free, 2-week residential camp for Class 9 students to ignite interest in space science, technology, and STEM careers through lectures, hands-on activities, and visits to ISRO centers, aiming to "catch them young" and foster future space innovators

Global Impact

India’s achievements in space sciences demonstrate a unique blend of affordability, innovation, and reliability. By offering satellite launch services to other nations, contributing to disaster relief through space-based data, and engaging in international partnerships, India has positioned itself as a responsible and influential spacefaring nation.

India’s journey in space sciences reflects its commitment to scientific excellence, technological self-reliance, and global cooperation. These achievements not only strengthen national capabilities but also inspire future generations to explore the frontiers of space.



Defence Technologies for Societal Benefit

Dr. Vepakomma Bhujanga Rao
Chairman, KIMS Foundation & Research Centre
Former, Distinguished Scientist & Director General, DRDO and
Former ISRO Chair Professor
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Defence Research and Development Organisation (DRDO) is India's premier research and development agency dedicated to empowering the nation with cutting-edge indigenous defence technologies and systems. Established on the first day of 1958, DRDO plays a crucial role in ensuring national security.

Peace is essential for progress and prosperity. DRDO adheres to the maxim: "We want peace. So, we prepare for war." Our nation's philosophy has deeply ingrained this principle since ancient times. India's long history—along with that of the rest of the world—demonstrates the harsh reality that only strong nations can afford the price of peace. The DRDO has significantly empowered India with cutting-edge defence technologies and continuously strives for self-reliance. It is renowned for its indigenously developed strategic platforms and technologies, which have enhanced our military capabilities.

DRDO has instilled in the nation a sense of pride by equipping India's defence forces with a variety of advanced indigenous defence technologies, weapons systems, and platforms. The strategic systems it has developed are of such a calibre that no financial resources could have sufficed to import them.

On 27 March 2019, a significant day for India, DRDO demonstrated the might of one of its homegrown, cutting-edge technologies. The Hon'ble Prime Minister Narendra Modi himself announced the success of the indigenous ASAT weapon, codenamed 'Mission Shakti', to the world. In his tweet, he declared that India is only the fourth country to possess such an advanced technology capability. The entire effort is indigenous. India stands tall as a space power! It will enhance India's strength and security while promoting peace and harmony.

Dr. Kalam became the first-ever DRDO scientist to receive India's highest civilian honor, the Bharat Ratna, for his crucial role in weaponizing nuclear power for deterrence, which ensured that the missile program stayed on the right course by advancing strategic missile programmes to respectable levels of maturity and bringing DRDO into delivery mode. Dr Kalam subsequently became President of India, which was a proud moment for all Indians.

The development of advanced ballistic missile strategic systems includes Agni 5, the long-range ballistic missile capable of delivering nuclear weapons to targets located even beyond 5,000 km; K4 and K15, the submarine-launched ballistic missiles, which, along with the nuclear-powered submarines, the Arihant series, provide a credible nuclear deterrent that incorporates both an element of surprise and second-strike capabilities. The world's fastest supersonic cruise missiles, BrahMos and missile like Akash, and many other technologies are some examples of the technological excellence of DRDO and the country as a whole. Electronic warfare systems, early warning and control systems (AEWC), a wide spectrum of radars, electro-optic sensors, laser instruments, supercomputers, cybersecurity systems, and secure communication systems are all developed by DRDO. In naval warfare, underwater weapons like the Varunastra, a heavyweight torpedo; the TAL, a lightweight torpedo; and various world class sonars for ships and submarines were developed and being deployed by the Navy.



Dr V Bhujanga Rao

Dr Vepakomma Bhujanga Rao is a distinguished Indian scientist, technologist, and strategic leader whose career spans more than four decades across defence R&D, naval systems, ocean engineering, acoustics, biomedical innovation, and science administration. Widely respected for his multidisciplinary expertise and institution building leadership, he has played a pivotal role in shaping India's capabilities in underwater defence technologies and advanced engineering systems.

Dr Rao is currently the Chairman of KIMS Foundation & Research Centre at Hyderabad. He was Former Distinguished Scientist and Director General of DRDO (Naval Systems), Former ISRO Chair Professor, NIAS, IISc campus, Bangalore and also Former Director of Naval Science & Technology Laboratory, Visakhapatnam

Dr Rao has strong academic foundation across physics, mechanical engineering, and management and holds doctoral degrees in Mechanical Engineering and physics and honorary doctorates. He has been recognized with multiple academic distinctions and fellowships. Dr. Rao is widely published in national and international journals and is recognized with numerous national awards, academic honors, and fellowships for his contributions to science, technology, and strategic innovation. VASVIK Award, Stanley Ehrlich Award of Acoustical Society of America (USA) and National Award for the Empowerment of Persons with Disabilities are some of the prestigious awards received by Dr Rao. His career reflects a deep commitment to scientific excellence, national service, and human centric innovation, making him one of India's most respected voices in defence technology and applied research.

Dr Rao is a scientist with rare breadth, Dr. Rao's technical contributions span underwater acoustics, bio acoustics, aero acoustics, hydrodynamics, shock and vibration engineering, meta materials, ship magnetics, underwater electric fields, radar and infrared signatures, underwater explosions, and machinery condition monitoring. His work has influenced both defence technologies and civilian applications, including medical devices, implants, and assistive technologies. Dr Bhujanga Rao was expert in the field of Naval weapon systems, warship design, submarine and submersible design technologies for the Indian Navy. Dr Rao did pioneering work on naval stealth technology hardware to make our ships difficult to detect by the enemy in any hostile situation, for this work he has been nick named "Stealth Man". Dr Rao is a leading expert in designing infrared suppression devices for ship exhaust systems, crucial for evading missile attacks. Holding a joint patent with product commercially installed on 48 Indian naval ships.

Smart mines and various soldier support systems were designed to accommodate the anthropometric parameters of native soldiers, and the challenging climatic conditions and terrains found in diverse battlegrounds were also developed.

The arena of operation for DRDO's technologies extends from the depths of oceans to the world's highest mountains, from scorching deserts to the extreme cold of Siachen, and from the high-humidity jungles of Northeast India to the dry cold deserts of Ladakh.

According to a parliamentary panel, India's defence R&D arm, DRDO, has provided 2.64 lakh crore worth of arms to armed forces over the last five years. DRDO patents are available on the DRDO website for use by industries. This allows private companies to use military-grade technology and become self-reliant.

Indian startups in the drone and EV sectors are currently using battery technologies and sensor designs developed by DRDO to build products faster than global competitors. The organisation has shown how Companies can move beyond quick fixes and embrace indigenous R&D to cut costs. With DRDO being part of the Ministry of Defence of the Government of India, only a few of it's achievements get highlighted. Details of its activities, including the challenges and roadblocks, as well as many of its accomplishments, remain away from the public eye.

Use of DRDO Products and Technologies in Civilian Applications

DRDO technologies often have "dual-use" potential, serving both military and civilian needs. Mechanisms for this transition are facilitated through the Transfer of Technology (ToT) process, where patents and know-how are shared with Indian industries. Few examples of civilian applications are mentioned here,

- **Healthcare:** During the COVID-19 pandemic, DRDO developed and transferred technologies for ventilators, N99 masks, hand sanitisers, personal protective equipment (PPE) coveralls with sealant used in submarines, and mobile testing labs to the private sector for mass production and use in hospitals.
- **Materials & Textiles:** Technologies for advanced materials, such as high-strength steel for naval vessels and specialised protective clothing for extreme weather, have applications in other heavy industries and adventure sports. Graphene-based e-textiles are also being developed for potential clothing applications.
- **Waste Management:** Low-cost bio-digesters developed for military use in high altitudes have been successfully applied to treat human and animal waste in civilian areas like the Dal Lake in Kashmir and by the Indian Railways in Vande Bharat Trains.
- **Navigation & Electronics:** Technologies like GPS and GLONASS satellite navigation receivers and various electronic systems have clear civilian market potential.
- **Infrastructure:** An "Expandable Mobile Shelter" technology was transferred to industry, which could be used for rapid deployment of medical camps or temporary housing during disasters.

How DRDO Helped MSMEs?

- DRDO has put in place several policies and initiatives to foster the growth and participation of MSMEs in the defence ecosystem and national development:
- Technology Transfer (ToT): DRDO transfers its developed technologies to Indian industries, including MSMEs, without ToT fees and zero royalty for products supplied to the Indian Armed Forces or government departments.
- **Financial Support:** The Technology Development Fund (TDF) scheme provides grants-in-aid and funding (up to 90% of project costs, with a limit of 10crores) to MSMEs and start-ups for the innovation, research, and development of indigenous defence technologies and prototypes.
- **Innovation Ecosystem:** DRDO is a key partner of the Innovations for Defence Excellence (iDEX) framework, which provides grants and support to MSMEs and start-ups to carry out R&D with the potential for future adoption in defence and aerospace.
- **Access to Patents and Facilities:** DRDO patents are available for use by Indian industries free of cost. MSMEs can also access DRDO's world-class R&D and test facilities on a payment basis to test their products.
- **Procurement Policies:** Specific government policies reserve orders (up to 100 crore/year) for MSMEs in defence acquisitions, ensuring market access for their products.
- **Collaboration and Handholding**: DRDO engages with MSMEs through conclaves and outreach programs, providing technical consulting and support to help them absorb complex technologies and become reliable partners in the supply chain.
- **Vendor Development:** The "Development cum Production Partner" (DcPP) model ensures industries are involved from the early stages of development, creating a cheaper and faster supply chain and treating suppliers as R&D partners.

Materials Research for National Strategic Programs: Marching towards Viksit Bharat 2047

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Hyderabad-500 058.

India will celebrate its 80th Independence Day in 2026. The country has come a long way since independence, from being an impoverished nation with a GDP of less than ₹ 3 Lakh Crores to being the fourth largest economy in the world with a GDP of ~ ₹418 Lakh Crores and contributing to about 3.45% of the world's GDP. This phenomenal growth of the country has been propelled by services, manufacturing industry, agriculture and consumption. The Mining & Metals sector has played a significant role in shaping this growth story accounting for about 2.5% of the GDP and is expected to increase to more than 8% by the end of this decade. India as on day produces 95 minerals including 3 atomic minerals. Only four steel companies (Bengal Iron & Steel Company, Tata Iron & Steel Company, Indian Iron & Steel Company & Mysore State Iron and Steel Works later renamed VISL) and Indian Aluminium Co. existed in India at the time of independence. From its humble beginnings producing a mere 1.7 million tonnes of pig iron and 25,000 tonnes of aluminium annually, this country has transformed into a global industrial powerhouse. It now ranks as the world's 2nd largest producer of crude steel (149 million tonnes) and the 4th largest producer of aluminium (4.2 million tonnes). Additionally, it holds significant global positions in non-ferrous metals, ranking 4th in lead (3,93,000 tpa) and zinc(8,27,000 tpa) production and 6th in titanium(500 tpa) production. The country also produces significant amounts of copper (573,000 tpa), silver and a range of ferroalloys. From being a non-existent player in renewable energy, space technologies and atomic energy, today we rank 4th in renewable energy (3rd in solar energy with more than 50 GWe installed capacity and 4th in wind power), 5th among international space agencies and 12th in atomic energy (24 reactors with close to 8180 MW of installed capacity). Further, the country has evolved into a globally recognized leader in strategic and cutting-edge technologies. This progress is anchored by the development of sophisticated weapon systems including Agni intercontinental ballistic missiles, anti-satellite systems, indigenous aircraft carriers and fighter aircraft. In the space sector, the country has successfully deployed communication and remote sensing satellites via the PSLV, GSLV, and LMV3 launch vehicles, sent two citizens into orbit, and reached the Moon, Mars, and the Sun. In all of these national missions, development of strategic and critical materials has played a key role in the ultimate success.

Materials are the backbone of any engineering structure and strategic materials technologies are therefore closely guarded, in view of their dual use. Indian national strategic programmes of defence (integrated guided missile development program), space (Polar and Geosynchronous satellite launch vehicles) and atomic energy (different types of nuclear power reactors), are symbols of the country's pride and owe their success largely to the dedicated efforts of scientists towards development and indigenization of performance critical systems. Technology denials have in a way indirectly helped the country to achieve self-reliance and in establishing large scale facilities required for meeting the demands of these strategic sectors. It is an undeniable fact that successfully meeting the critical requirements of all materials for strategic programmes indigenously has been made possible through the dedicated efforts of teams which overcame several hurdles and challenges.



Dr. S.V.S. Narayana Murty

Dr. S.V.S. Narayana Murty has received his B.E. from Andhra University, Visakhapatnam, M.E. from IISc-Bangalore and Ph.D. from IIT-Bombay, all in Metallurgical Engineering. Presently, he is the Chairman & Managing Director of Mishra Dhatu Nigam Limited, Hyderabad. He joined Vikram Sarabhai Space Centre, Trivandrum in 1993 and worked extensively on the development of ultrahigh strength steels, titanium alloys, superalloys and aluminium alloys. He was a post- doctoral fellow at the Steel Research Centre, National Institute for Materials Science, Japan (2003-2006) and worked on the development of ultrafine grained steels. During 2021-2025, he was with Liquid Propulsion Systems Centre (ISRO), Trivandrum. At LPSC he was responsible for the indigenization and supply of materials for earth storable, cryogenic, semi-cryogenic stages as well as for satellite propulsion systems for Indian space program. His areas of expertise include aerospace materials development and processing, material testing, characterization, failure analysis of aerospace components and additive manufacturing.

Dr. Narayana Murty is a recipient of Young Metallurgist Award (2001) and Metallurgist of the Year award (2018), both from Ministry of Steel, Government of India. He was a member of ISRO Team excellence award for "Indigenization of Copper alloy Cu-Cr-Ti-Zr thrust chamber of cryogenic and semi-cryogenic engines" (2012). For his post-doctoral work at NIMS, he has received AIDA Technology Innovation award by Japan Society for Technology of Plasticity (2009) for Development of Ultrafine Grained Steels. He was awarded the National Failure Analyst award (2021) by the Society for Failure Analysis and G.D. Birla Gold Medal (2022) by the Indian Institute of Metals.

Dr. Murty is an elected fellow of the Andhra Pradesh Akademi of Sciences, (2017) and Indian National Academy of Engineering (2021). He is the Editor-in-Chief of the transactions of the Indian Institute of Metals, published by Springer. He is on the editorial boards of Encyclopedia of Aluminium alloys, ASTM Journal of Materials Performance and Characterization and Journal of Engineering Failure Analysis. He is also a member of the American Society for Metals (ASM) Handbook committee. He is the National Vice President, Indian Institute of Metals, Kolkata. He is the Chairman of The Indian Institute of Welding, Hyderabad Chapter. He is a member of research council of CSIR-AMPRI, Bhopal, Board Member of Nuclear Fuel Complex, Hyderabad, Board Member of Indian Iron & Steel Sector Skill Council, Kolkata, and technical advisory group of ARCI, Hyderabad. He is in the list of top 2% scientists published by Stanford University. He has supervised 8 Ph.D. students and more than 25 masters students. He is author of several ISRO internal technical reports and over 325 publications in international peer reviewed journals.

While significant progress has been made post-independent India as mentioned above, leading to atma nirbharta in several fields, there are many ambitious targets ahead to realise the vision of Viksit Bharat 2047, the occasion to commemorate 100 years of India's Independence. Due to changing geo-political situations, supply chains are getting disrupted which can affect growth in long run. Natural resources such as critical minerals are being bargained and are the currency of the new world. Indigenous development of materials starting from conversion of ore to pure metals and manufacture of alloys from the produced metals as a long-term strategy. Recycling of metals is another important aspect that needs to be pursued and metallurgical research towards this needs to be initiated. Precious and critical metals extraction from tailings is another area that needs to be thought of. Many ambitious national projects are under development and uninterrupted materials security is essential to realise the plans. Indigenous development and production of the equipment that are required for materials extraction, mineral processing, testing and characterisation at various levels is another area that needs serious introspection. Import of strategic materials and systems should slowly be brought down with their progressive indigenisation. While atma nirbharta is towards achieving self-sufficiency, Viksit Bharat 2047 envisages India to become a global leader to collectively achieve in the coming 21 years. The challenges to meet the economy of scale should be achieved by then.

Human resources are another area that needs to be seriously contemplated. Technologies are rapidly changing and curriculum that meets the future job requirements including practical training programs holds key. Artificial intelligence/ machine learning in materials processing and manufacturing are changing the way systems are realised. Newer technologies such as reuse of spent stages in rocketry are reducing the cost of launching payloads in to orbit significantly. Innovative technologies using drones are in news frequently. In order to achieve Viksit Bharat, it is essential to design and build the systems indigenously. Overcoming the limitation of designing systems indigenously and fabricating them economically is the need of the hour. Therefore, the purpose of this presentation is to highlight the recent advances in materials research towards achieving Viksit Bharat 2047.



Bridging the Communication Gap: Making Science & Technology India's Shared National Dream

Shri Pallava Bagla
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The Missed Moment

On a crisp morning in 2025, India made history. Gaganyatri Shubhanshu Shukla soared into space, carrying the hopes of a billion people. It was a moment that should have electrified the nation. After all, India had spent 550 crore on his ticket to the stars. Yet, the buzz fizzled out almost as soon as the rocket cleared the tower. Why? Because the story never reached the people.

Contrast that with the night in 2019 when the Vikram lander attempted a soft landing near the Moon's South Pole. The entire country stayed awake past midnight, hearts pounding, eyes glued to screens. When the lander failed, tears rolled down the ISRO chairman's cheeks—and a billion Indians cried with him. That was science communication at its rawest: emotional, human, unforgettable.

The Gaganyatri mission's muted reception was a wake-up call. Technology alone doesn't inspire. Stories do.

Why Communication is the Missing Link

India dreams big. A 1 lakh crore fund for emerging technologies, ambitions in quantum computing, AI, green hydrogen, and interplanetary missions—all point to a nation on the move. But innovation without communication is like a rocket without fuel. If citizens don't understand or trust these advances, progress stalls.

Science communication is not a luxury. It is a democratic necessity. It empowers people to make informed choices, counters misinformation, and builds national pride. Yet, in India, this compact between science and society is fraying.

The Challenge: Complexity Meets Curiosity

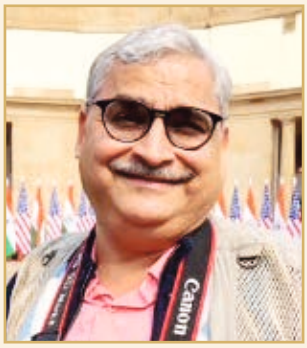
Communicating science is never easy. Complex concepts intimidate people, even though most citizens have a genuine interest in health, environment, and technology. The challenge lies in simplifying without trivializing and informing without sensationalizing.

In today's hyper-connected world, misinformation spreads faster than facts. Social media amplifies both truth and rumour. If science remains cloistered in labs and jargon, the dream of an Atma Nirbhar Bharat will falter.

The Tightrope Walk

Reporting high technology is exhilarating—but it's not for the faint-hearted. Space, nuclear energy, and defense are cloaked in secrecy for valid reasons. As a journalist, you walk a razor-thin line between informing the public and safeguarding national security.

I've walked that line for over three decades. From missile development in Hyderabad to nuclear reactors in Kudankulam, from ISRO's clean rooms to Rosatom's Arctic labs—I've seen the inside of places few outsiders ever enter. Access is hard-won. Permissions take weeks, sometimes months. Inside, every protocol matters. Surreptitious shooting? A complete no-no. The "Lakshman Rekha" drawn by security agencies is sacrosanct.



Shri Pallava Bagla

Shri Pallava Bagla is a charismatic Indian science communicator respected for his deep understanding of his country's S&T system. He has won many national and international awards for his work. Explaining complexities of science in a simple language is his forte. His pioneering work shows casing India's missions to Mars and Moon has been applauded this aired in English and Hindi for New Delhi Television and online where he is a Consulting Science Editor. In his over two decades of writing for the prestigious American weekly Science, his stories have highlighted India to the world. He anchored a weekly program 'Life in Science with Pallava Bagla' on the India Science Channel, making 76 half hour documentaries on Indian S&T.

He won three National Awards for his science writing and in 2010, he was awarded the `David Perlman Award for Excellence in Science Journalism' considered the Oscar of science journalism and given by the American Geophysical Union, Washington DC, for his landmark writings which exposed the Himalayan glacier blunder by the UN's Intergovernmental Panel on Climate Change (IPCC). Winner of Red Ink Award in 2021 by Mumbai Press Club. He won an award by the Academy for Science, Technology and Communication in 2025.

He runs a regular photo blog on Twitter, Facebook and Instagram titled `Enjoy Nature' and used to pen a weekly column of S&T for the Press Trust of India (PTI) and has authored several books. He is photographer for the world's top photo agency Getty Images. His YouTube Channel `New Frontiers in Science and Development' is very popular. Author of several books, he also served as `Shri Raman Pai chair Visiting Professor in Science Communication' at the National Institute of Advanced Studies, Bengaluru which resulted in the book `Bridging the Communication Gap in Science and Technology: Lessons from India' edited by Pallava Bagla and V. V. Binoy and published by Springer in 2017.

He served as President of the International Science Writers Association and was a member of the Executive Board of the World Federation of Science Journalists. A member of the Managing Committee for the Working News Cameramen's Association.

Yet, the government also wants to showcase its technological edge—to inspire citizens and deter adversaries. Balancing these competing demands is an art. And it starts with trust—earned through years of ethical reporting.

Lessons from the Frontlines

Humanize Science

Audiences connect with faces, not formulas. When I reported on Mangalyaan, India's Mars mission, I didn't just explain orbital mechanics—I showed the engineers who built the spacecraft, their hopes and fears.

Avoid 'WhatsApp University'

In the age of viral forwards, accuracy is a casualty. Rely on experts, peer-reviewed journals, and credible sources. A single error can wreck careers and erode public trust.

Be Multilingual & Multi-Platform

Science communication must speak the language of the masses—literally and figuratively. For me, reaching Hindi audiences is as important as English. Today, MOJO—Mobile and Online Journalism—has made reporters one-person armies. Shooting, editing, and transmitting, all on a smartphone. It's liberating, but also demanding.

Prepare for Pushback

When I reported on Bt Cotton in 2002, Monsanto slapped me with a legal notice. My obsessive record-keeping saved me. Later, they gave me access. Fair journalism wins respect—even from adversaries.

Case Studies: When Communication Made or Broke History

Mangalyaan (2014): India's low-cost Mars mission captured global headlines because ISRO and the media worked in tandem to tell the story.

Vikram Lander Failure (2019): The nation's heartbreak was palpable, but post-failure opacity dented confidence.

Covid-19 Pandemic (2020): Clear messaging on masks, vaccines, and hygiene saved millions.

Gaganyatri Mission (2025): A 550 crore ticket to space, yet public engagement was lukewarm—a missed opportunity.

The Historical Lens

India's tryst with science communication began early. From the Green Revolution that turned a food-deficit nation into a surplus powerhouse, to the nuclear tests of Pokhran that announced India's strategic autonomy, stories shaped public perception. When Prime Minister Lal Bahadur Shastri coined "Jai Jawan, Jai Kisan," it was more than a slogan—it was science communication at its finest.

Fast forward to today: satellites guide farmers, AI predicts weather, and biotech promises drought-resistant crops. Yet, agriculture reporting remains "unsexy." Half our population depends on farming, but stories about soil health rarely trend. This is where communicators must step in—making the invisible visible.

The Future: Science Communication as a National Priority

India's technological ambitions are accelerating. But scepticism and misinformation thrive in the absence of clear communication. Here's what needs to happen:

Institutionalize Science Communication. Every major S&T initiative should have a dedicated outreach plan.

Train Specialized Journalists. Universities must offer courses in science journalism and multimedia storytelling.

Leverage Social Media Responsibly. Use platforms to inform, not inflame.

Celebrate Scientists as Public Figures. Just as cricketers and film stars dominate headlines, scientists should be household names.

Personal Encounters That Shaped My Journey

I've reported from over 60 countries, met Nobel laureates and missile makers, and stood inside nuclear plants where cameras are forbidden. I've seen tears of triumph and heartbreak—from ISRO's Mars mission to the failure of Vikram. I've faced legal threats, political storms, and the occasional smear campaign. Through it all, one truth stands out: science stories matter. They shape policy, inspire youth, and build national pride.

When I interviewed Prime Minister Manmohan Singh in 2012, he told me foreign NGOs were hindering India's development by opposing atomic energy and GM crops. That explosive statement didn't come from a political reporter—it came from a science journalist who refused to take no for an answer. Now the SHANTI Act the new atomic energy Act 2025 promises to unleash the hither too secretive atomic energy sector to the private sector, an amazing turn in India's policies.

The Call to Action

The twenty-first century belongs to Asia—and India is ready for take-off. But innovation without communication is like a rocket without fuel. We need an army of science communicators who can decode complexity, inspire curiosity, and empower citizens to make informed choices.

An Atma Nirbhar Bharat needs not just engineers and scientists but storytellers who can make science accessible and exciting. Do not get intimidated by high technology—it can be highly rewarding. Audiences love to hear about new frontiers being conquered through human innovation.



Mainstreaming Science Journalism: A View from the Academy

Dr Usha Raman
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For as long as the enterprise and the profession of journalism has existed, the coverage of scientific and technological advancements has been an integral part of media content. While inventions and discoveries (often labeled "breakthroughs") have been the mainstay of this beat, the media has also given space to the people, places, processes, and politics in the fields of science and technology. The science beat has had a steady presence in most large media outlets, stepping in to provide informed and in-depth reporting at times when there is a significant science angle to a current development or event—such as natural disasters, epidemics, major research findings, etc. In recent times, many major stories have had a distinct science or technology component, and the expertise and perspective that an experienced science journalist can bring has been extremely valuable. This was quite visible during the COVID-19 pandemic, for instance, when there was a need to unpack the science behind vaccine development, and to understand the epidemiology of the disease, among other things.

Despite the widespread recognition that science and technology permeate all aspects of life and the media plays an important role in building critical literacies in these areas, most journalists stumble into and make their own way around the world of science writing. Many would add health to this mix, although in most media companies' health is treated as a distinct beat from science and technology—and increasingly, these are also being differentiated. For the purposes of this talk, to keep things simple and clear, let us focus on what we might call science journalism, as different from both health and technology. The latter, particularly, has a different kind of resonance today as our lives are increasingly shaped and mediated by technologies of various kinds, from genetic engineering that alters our food to digital and networked platforms that have become fundamental to work, leisure, and communication. Of course, science cannot be strictly siloed from either health or technology, and most science journalists also pay attention to these "neighboring" beats, and many complex stories will contain multidisciplinary elements that need an appreciation of the interconnected nature of all life.

What is the Scope of Science Journalism?

Science journalism focuses on the process, products, policies, and politics of science. While the definition of science itself may vary, we generally understand it as all systematic forms of knowledge production, where propositions are made, carefully examined using a range of accepted methodologies, and inferences derived that can be tested and verified independently. In recent years the term "science" is also taken to mean the social and human sciences, not only laboratory-based or "natural" sciences. Clearly, those who do science journalism must have an appreciation of and a curiosity about the field(s) they are covering, but they do not need to be specialists themselves. The science journalist is an interlocutor for the world of science, making it intelligible to the lay public. Some large media houses have dedicated science writers and editors, but by and large, general assignment reporters take on science stories when the need arises, as it may be considered too expensive to put someone on a specialized field full time. Similarly, some media outlets have a dedicated space for science stories while in others, they are not specially marked. One can debate about which model works better.



Dr Usha Raman

Dr Usha Raman is a writer and media studies scholar based in Hyderabad, recently retired after many years of teaching at the University of Hyderabad. Prior to entering academia, she worked as a freelance journalist and science communication practitioner for close to two decades. Her writing, which spans the academic and popular, has appeared in multiple media outlets. Recent co-edited books include Feminist Futures of Work (2023), Childscape, Media Scape: Children and Media in India (2023), and Digital Expressions of the Self(ie): The Social Life of Selfies in India (2024). She edits a magazine for schoolteachers, Teacher Plus. She has published a collection of poetry, All the Spaces in Between (Writers Workshop, 2009), and her debut novel, Polite Conversations (BEE Books), was published in 2024.

How are Science Journalists Produced?

In India, few university-based or institutional journalism programmes have a specialization in science journalism, although a few may have a single course as an elective/optional. Despite this, there is a healthy interest in science journalism particularly among the younger crop of journalists, and this interest has been encouraged by a range of short-term courses and online programmes offered by scientific research institutes such as the National Centre for Biological Sciences (NCBS) and IISER Pune. Interestingly, many of today's science journalists are scientists-turned-journalists rather than journalists writing about science. It would be important to examine why journalism departments have not placed more emphasis on including science reporting as an essential part of their curriculum, producing this gap in training.

What is the appetite for science stories?

In some ways, there has been no better time for science reporting. Practically every day, in every media space, there are exciting stories that go behind and underneath the scientific developments of the day, explaining how things work, what a new discovery means, what kind of funding made it possible, and who the people behind it are. There is short form and long form, podcasts and YouTube videos, with interesting new formats being experimented with. Yet this has not reflected in university curricula in specific ways, and such training tends to be provided through short courses offered by scientific institutions. Essentially, it is the establishment of science that is driving public science communication, rather than institutionalized journalism training. This has consequences for the critical scrutiny of science as a system, which requires a combination of scientific literacy and journalistic acumen.

The talk will explore these three themes in more detail, looking at how journalism courses can better prepare young people to report on and write about science.



Grappling with the Deluge of Non-communicable Diseases in India

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India is experiencing a significant rise in non-communicable diseases (NCDs). The most prevalent NCDs include cardiovascular diseases, diabetes, chronic respiratory diseases, and cancers. In 2025, non-communicable diseases (NCDs) remained the leading cause of death in India, accounting for over 60% of all mortalities. This "deluge" is driven by rapid urbanization, sedentary lifestyles, and poor dietary habits. Grappling with this challenge requires a multi-pronged approach involving lifestyle modifications, early detection, and strengthening the healthcare system.

What Are the Most Prevalent NCDs?

Non-communicable diseases are chronic conditions that are not transmissible from person to person and result from a combination of genetic, physiological, environmental, and behavioural factors.

The primary NCDs in India are:

- Cardiovascular Diseases (CVDs): heart attacks and strokes, which are the leading cause of death in India
- Diabetes: we have a high prevalence of diabetes and studies show a significant increase in recent year
- Chronic Respiratory Diseases: Conditions like Chronic Obstructive Pulmonary Disease (COPD) and asthma are prevalent, due to tobacco smoking and poor air quality
- Cancers: Common site include breast, cervical, oral cancers, upper aerodigestive cancers, lung and stomach cancers
- Rapid Urbanisation is perhaps one of the major drivers for their increase

How to Grapple with Them?

The response to the NCD epidemic requires action at individual, community and governmental levels, focusing on modifiable risk factors such as:

- unhealthy food habits
- physical inactivity or lack of exercise
- tobacco in any form and alcohol
- awareness of preventive health

Individual and Community Measures:

- Healthy Diet: a diet rich in fruits, vegetables and whole grains while limiting processed foods, sugar rich beverages, salted foods and unhealthy fats, including fast food
- Regular Physical Activity: at least 40 minutes of vigorous every day in the form of brisk walking, cycling, swimming. Encouraging games and sports in every school and college



Dr D Raghunadharao

Dr. D. Raghunadharao is one of India's distinguished leaders in Medical Oncology, with more than four decades of dedicated service in cancer care clinical research, training, teaching and patient advocacy. He is known for his deep expertise in chemotherapy and comprehensive cancer management. Dr. Rao has served in leading medical institutions in Hyderabad. Patients and peers regard him as one of India's notable oncology specialists, particularly valued for his clinical judgment, compassionate care, and contributions to cancer treatment practices. His work is marked by a rare blend of scientific rigor, clinical precision, and deep compassion for patients and families. Dr. Raghunadharao's contributions extend beyond the clinic—he has been actively involved in public education, early detection initiatives, and community level cancer awareness programs.

Dr Raghunatharao is a stalwart in establishing cancer hospitals, cancer registries and molecular oncology labs. He established a comprehensive cancer hospital at Visakhapatnam, for the Tata Memorial Hospital, Mumbai, under the Department of Atomic Energy, Government of India.

Dr Raghunatharao was the National Coordinator for training government doctors in Cancer Screening & Prevention under the NRHM-NCD program during 2011 to 2013. He has collaborations with several prestigious organizations like Breast International Group, University of Oxford Osmania University, Central University, NIN, CCMB and ICRISAT in pre-clinical & clinical research activities. He pioneered phase 1 trials in cancer drugs and completed over 80 clinical trials in all phases since 1993. He has over 280 publications in peer reviewed journals.

Dr Raghunatharao is elected Fellow of the American College of Physicians, Royal College of Physicians of London and Andhra Pradesh Academy of Sciences. Presently President of Andhra Pradesh Academy of Sciences. He was awarded. Dr. B C Roy National Award for Excellence in Promotion of Oncology by Medical Council of India.

- Avoid Tobacco and Alcohol: Quitting smoking and reducing alcohol consumption can drastically lower the risk of developing several NCDs. It is pertinent to note that most healthcare workers are ignorant of how to wean an addict from tobacco or alcohol. Support groups and cessation programs are of great help.
- Manage Stress: Utilize stress management techniques such as mindfulness and exercise, as chronic stress contributes to conditions like high blood pressure and heart disease.
- Regular Screening: Participate in regular health check-ups and screening for conditions like hypertension, diabetes and common cancers for early detection and timely intervention.
- Inclusion of vaccination against human papilloma virus (HPV) for both boys and girls into the universal vaccination program and cervical cancer screening with HPV in every woman above 30 years of age should be implemented.

Government Initiatives and Strategies

The Government of India has initiated several programs to tackle the NCD burden, primarily through the National Programme for Prevention and Control of Non-Communicable Diseases (NP-NCD).

While it looks good in paper, it needs to be properly implemented. Its success depends on being integrated and assimilated into the existing health care systems.

- Strengthening Primary Healthcare: The Ayushman Bharat Health and Wellness Centres (AB-HWCs) scheme promotes wellness activities and provides NCD screening (for people over 30 years old) at the community level.

- Awareness Campaigns: Initiatives like the Fit India Movement, Eat Right India Movement (promoted by FSSAI), and various Yoga-related activities by the Ministry of AYUSH aim to promote healthy lifestyles and raise public awareness.
- Policy and Regulation: The government implements strong regulatory measures such as the Cigarettes and Other Tobacco Products (Prohibition of Advertisement and Regulation of Trade and Commerce, Production, Supply and Distribution) Act, 2003 (COTPA 2003) to discourage tobacco use.
- Affordable Treatment: Schemes like the Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP) provide quality generic medicines at affordable prices, and the AMRIT initiative offers discounted medicines and implants for diseases like cancer and cardiovascular conditions.
- Leveraging Technology: The National NCD Portal and mobile applications are used for population-based screening, data management, and teleconsultations to improve monitoring and access to care.

Moving from advocacy to action is the urgent need and some of these aspects will be discussed during the presentation



Nutrition Policies and Programmes in India: A Constant Communication Dilemma Between Facts and Fiction

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India's nutrition landscape today presents a paradox - not just of the co-existence of the double/triple burden of malnutrition, but also of the strange and emerging nutrition communication dilemma. On the one hand, the country has one of the world's most extensive portfolios of nutrition policies and programmes, ranging from supplementation, fortification, and food security initiatives to large-scale behaviour change communication (BCC) efforts. On the other, the public discourse around nutrition is increasingly fragmented, contested, and vulnerable to misinformation, half-truths, and oversimplified narratives. This presentation will attempt to examine the persistent communication dilemma that lies at the heart of India's nutrition policies and programmes—the uneasy tension between scientific evidence and popular, media-driven, or market-amplified beliefs driven by misinformation.

Drawing upon published evidence, including earlier work on nutrition communication in India (Gavaravarapu, IJMR, 2019), and experiential insights from policy engagement, research, and programme implementation, this presentation argues that communication is not a peripheral concern but a central determinant of nutrition outcomes. Nutrition communication in India has historically been approached as a unidirectional exercise - informing people about what to eat and what to avoid. However, food choices and nutrition-related behaviours are shaped by complex interactions between individual knowledge, socio-cultural norms, economic constraints, food environments, media narratives, and trust in institutions. Treating communication merely as information dissemination risks widening the gap between policy intent and public action.

India's nutrition policies have evolved in response to changing epidemiology - from undernutrition and micronutrient deficiencies to the growing burden of overweight, obesity, and diet-related non-communicable diseases. Yet, communication strategies have not always evolved at the same pace. Messages rooted in technical correctness often fail to resonate with lived realities, while simplified or sensationalised narratives gain rapid traction through mass media and digital platforms. Controversies around food safety, fortification, ultra-processed foods, and dietary fats and sugars illustrate how scientific uncertainty, media amplification, and low public trust can distort risk perception and influence consumption behaviours disproportionately.

A key challenge is the mismatch between how scientific knowledge is generated and how it is consumed. Scientific evidence is inherently dynamic, probabilistic, and contextual. Experts are comfortable with uncertainty and revision, but the public often interprets changing recommendations as inconsistency or incompetence. In such an environment, nutrition policies, however evidence-based they are, are easily undermined by competing claims, commercial messaging, and anecdotal experiences. The result is confusion: whom should people believe, and why should they trust one message over another?

The talk further explores how nutrition programmes frequently overestimate the power of awareness creation while underestimating structural and environmental constraints. Many communication



Dr. Subba Rao M Gavaravarapu

Dr Gavaravarapu Subba Rao uniquely blends his social science roots with two decades of expertise in nutrition communication, public policy, and community engagement. His research explores the cultural and contextual factors shaping food environments, with significant work in food labelling, vendor education, workplace nutritional wellbeing and combating health misinformation. He has over 100 peer reviewed publications.

He served on the expert committee for India's 2024 Dietary Guidelines. He possesses direct, high-level policy experience, as the chair of the Scientific Panel on Food Labelling, Claims & Advertising at Food Safety & Standards Authority of India (FSSAI). He also is a member of the Working Group tasked with drafting 'Nutrition Strategy for India' constituted by NITI Aayog, India's premier policy think tank. He leads transformative initiatives like the "Let's Fix Our Food" consortium aimed at reducing consumption of HFSS foods among adolescents - the target demographics most affected by marketing of such foods. He led the development of digital tools like the NutritionAtlasIndia2.0 and innovative nutrition apps demonstrating a forward-thinking approach to disseminating guidelines effectively. He also actively translates science for the public through hundreds of awareness sessions and media engagements.

His contributions are well recognized with honours like the Outstanding Nutrition Scientist Award from Federation of Asian Nutrition Societies (FANS), the VN Patwardhan Prize from ICMR, Mid-Career Award from the American Society of Nutrition, Buti Science Communication Award from Gujarat Science Academy, PG Tulpule Oration Award 2025 to name a few. He is a fellow of the National Academy of Agricultural Sciences (FNAAS), India; the Royal Society for Public Health (FRSPH), UK. More recently he has been elected as the Fellow of International Union of Nutrition Sciences (FIUNS)

interventions focus on individual behaviour change without ensuring an enabling food environment—availability, affordability, accessibility, and acceptability of healthier choices (the 5As approach). Evidence from Indian programmes shows that short-term, information-heavy interventions may improve knowledge but rarely translate into sustained behavioural change unless supported by policy coherence, supply-side readiness, and social support systems.

Another dimension of the communication dilemma lies in agenda setting. Who defines the nutrition problem, which solutions are prioritised, and whose voices dominate the discourse significantly influence public understanding. Media narratives often privilege dramatic food scares or moralistic framings of diet, while structural determinants such as food systems, marketing practices, and socio-economic inequities receive limited attention. This selective visibility creates "discursive silences" that weaken policy legitimacy and public engagement.

The growing influence of food marketing and digital media. Aggressive advertising, emotional appeals, and persuasive design techniques shape food preferences, particularly among children and adolescents, often overpowering public health messages. In contrast, nutrition communication efforts are expected to be factual, cautious, and restrained—placing them at a competitive disadvantage in the attention economy. This asymmetry raises important questions about regulation, advocacy, and the ethical responsibilities of both the state and the private sector.

Importantly, the talk does not aim to frame communication failures as mere messaging problems. Instead, it positions communication as a transactional, trust-dependent process that must build response efficacy (ie., people's belief that they can act on advice and that such action will meaningfully benefit them). Without addressing risk perception, self-efficacy, and social trust, even the most scientifically sound policies risk being ignored, resisted, or misinterpreted.

The persistent dilemma between facts and fiction in India's nutrition policies and programmes underscores the need to reimagine nutrition communication as an integral component of policy design and implementation, rather than a post hoc add-on. Effective nutrition communication must be context-sensitive, theory-informed, multi-stakeholder, and aligned with food environments and regulatory frameworks. Bridging the gap between evidence and everyday practice requires humility from experts, transparency from institutions, and sustained engagement with communities.

ABSTRACTS OF PANELISTS

From Discovery to Dialogue: Reimagining Science Communication for a Sustainable Future with Focus on Nuclear Energy

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1. Preamble - Discovery to Dialogue

For much of the twentieth century, science progressed within a largely insular ecosystem. Discoveries were made in laboratories, validated through research and peer review, translated into technologies, and eventually deployed for societal benefit. Communication, when it occurred, was often unidirectional—scientists spoke, and society was expected to listen and accept. This "deficit model" of science communication presumed that public scepticism stemmed primarily from a lack of information and that supplying more facts would automatically lead to acceptance.

The twenty-first century has fundamentally altered this landscape. Societies today are more informed, more connected, and more questioning. Scientific and technological interventions increasingly intersect with public values, ethical considerations, environmental concerns, and intergenerational equity. Parallely, in an era of information abundance, misinformation travels faster than peer-reviewed research. Nowhere is this transformation more evident than in the discourse surrounding sustainability and climate change. The global transition towards low-carbon energy systems demands not only technological innovation but also broad societal understanding, trust, and participation.

In this evolving context, science communication must move beyond the domain of dissemination more towards dialogue. Dialogue implies listening as much as explaining, engagement rather than persuasion, and co-creation of understanding instead of unilateral messaging. Scientists are no longer mere generators of knowledge; they are also required to be ambassadors and stewards of public trust.

Nuclear energy presents perhaps the most complex and compelling test case for this transition. It is a proven low-carbon energy source with immense potential for supporting sustainable development, yet it remains encumbered by myths, public apprehensions, historical memories of accidents, and persistent misconceptions/misinformations. The challenge, therefore, is not solely technical, it is fundamentally communicative.

This article explores how science communication must be reimagined to support a sustainable future, using nuclear energy as a focal point. In the present day national and international context, it is imperative that the journey from discovery to deployment must be accompanied by an equally robust journey from discovery to dialogue.

2. Science Communication in the Era of Sustainability

2.1 Changing Paradigms in Science Communication: Science communication has evolved through several identifiable paradigms. The earliest approach, often described as the deficit model, assumed that scientific knowledge resided exclusively with experts and that public resistance arose from ignorance. Experience has shown the limitations of this approach. Increased information availability has not necessarily translated into increased trust.

Subsequent models emphasised engagement and dialogue, recognising that public attitudes are shaped not only by facts but also by values, emotions, cultural contexts and experiences. More recent thinking advocates co-creation, wherein stakeholders participate in framing questions, evaluating trade-offs, and shaping outcomes.

This shift is particularly relevant for technologies that carry perceived risks and long time horizons — attributes that strongly characterise nuclear energy. Communication, therefore, is very essential, but must be contextual, empathetic but transparent, while remaining scientifically rigorous.

2.2 Sustainability as a Communication Challenge: Sustainability itself is a complex, multi-dimensional concept. It encompasses environmental protection, economic development, social equity, and intergenerational responsibility. Communicating sustainability is inherently challenging because it deals with long-term consequences, probabilistic outcomes, and systemic interactions rather than immediate, visible benefits.

Energy systems lie at the heart of sustainability debates. Decisions made today about energy infrastructure will shape emissions trajectories, resource utilisation, and environmental footprints for decades in other words it is intergenerational. Communicating these long-term implications requires clarity, consistency, and credibility—qualities that must be carefully cultivated through appropriate mentoring.

In this setting, scientists and engineers must engage not only as technical experts but also as interpreters of complex systems for diverse audiences, bridging the gap between evidence and understanding.

3. Nuclear Energy in the Sustainability Discourse

3.1 Nuclear Energy and Sustainable Development: Nuclear energy occupies a unique position in the global sustainability landscape. From a lifecycle perspective, it is one of the lowest greenhouse gas–emitting energy sources. It provides reliable, baseload power with minimal land use and high energy density, attributes that are increasingly valuable as societies seek to decarbonise without compromising energy security.

Nuclear energy also aligns with several Sustainable Development Goals, including climate action, affordable and clean energy, industry and innovation, and responsible consumption of resources—particularly when closed fuel cycles and advanced reactors are considered.

Despite these attributes, nuclear energy is often marginalised in sustainability narratives. This disconnect underscores the importance of effective communication that situates nuclear power within the broader context of climate mitigation, resource efficiency, and long-term environmental stewardship.

3.2 Why Nuclear Communication Is Uniquely Challenging: Public perception of nuclear energy is shaped less by everyday experience and more by abstract notions of radiation, invisibility of risk, and historical events. Accidents, even when statistically rare, have disproportionate influence on public imagination. Radiation, unlike most industrial hazards, cannot be sensed directly, reinforcing fear and uncertainty.

Additionally, nuclear technologies involve long time scales—from reactor lifetimes to waste management—often extending beyond individual horizons. Explaining probabilistic safety, defence-in-depth, and residual risk to non-technical audiences requires careful framing, articulation with relatable analogies.

These challenges do not imply that concerns are irrational; rather, they highlight the need for effective communication that acknowledges fears while providing context, evidence and assurance.

3.3 Trust as the Central Issue: At the core of nuclear acceptance lies trust—trust in institutions, regulators, operators, and the scientific community. International experience demonstrates that public confidence is highest where transparency, independent regulation, and consistent communication are embedded in governance structures.

Trust cannot be built during crises alone; it must be nurtured continuously through openness, responsiveness, and demonstrated accountability. Communication, therefore, must be proactive rather than reactive and must be based on long term.

4. From Expert Narratives to Public Conversations

4.1 Translating Nuclear Science without Dilution: One of the persistent challenges in nuclear communication is balancing accuracy with accessibility. Oversimplification risks distortion, while excessive technical detail alienates audiences. Effective communication focuses on concepts rather than calculations, principles rather than parameters analogies rather than probabilities.

Radiation risk, for example, can be contextualised by comparisons with natural background radiation or medical diagnostics, provided such analogies are used responsibly. Nuclear safety can be explained through layered barriers, redundancy, and conservative design philosophies, reinforcing the message that safety is engineered, not assumed.

Similarly, radioactive waste must be discussed in terms of volume, containment, and long-term management strategies, avoiding sensationalism while acknowledging responsibilities.

4.2 Listening as a Scientific Responsibility: Dialogue requires listening. Public concerns often extend beyond technical risk to include issues of fairness, consent, and local impact. Treating these concerns as legitimate inputs rather than obstacles enhances credibility.

Engaging social scientists, behavioural experts, and local stakeholders can enrich understanding and improve communication strategies. The objective is not to persuade at any cost but to build shared understanding.

4.3 Role of Education, Museums, and Media: Education plays a foundational role in shaping attitudes towards science. Integrating nuclear science and radiation literacy into curricula demystifies concepts early. Science museums and centres offer experiential learning opportunities that make abstract ideas tangible and relatable.

Media engagement is equally critical. Scientists must be prepared to interact constructively with journalists, providing timely, accurate information and avoiding jargon. Training scientists as communicators is no longer optional; it is a professional responsibility. In this context, it is appropriate to mention the DAE-National Union of Journalists (NUJ) workshop programs at various units of the Department.

5. Indian Nuclear Programme: Communication Lessons and Opportunities

Nowhere is the shift from "deficit" to "dialogue" more critical—or more complex and challenging—than in India. As a nation attempting to lift millions out of energy inadequacy while adhering to strict climate goals, India serves as a global test bed for these communication principles. The Indian experience offers unique lessons in balancing technical ambition with the necessity of social consent.

5.1 A Long-Term Vision Anchored in Energy Sovereignty: India's nuclear programme stands as a testament to the visionary foresight of the Department of Atomic Energy (DAE). Long before "sustainability" and "circular economy" became global imperatives, DAE conceptualized a roadmap anchored in self-reliance and resource optimization. This is embodied in the three-stage nuclear power programme, which reflects a profound commitment to intergenerational equity.

However, communicating a vision that spans decades—culminating in Stage 3 (Thorium utilization)—presents a distinct challenge: maintaining public interest and national resolve over generations. To bridge this timeline, the narrative must evolve. We must frame the technical milestones not just as engineering feats, but as a journey toward Energy Sovereignty (Atmanirbhar Bharat). The commitment to a closed fuel cycle is not merely a technical choice; it is a strategic roadmap to energy security independence from volatile global fuel markets.

5.2 Transparency and Public Accountability: Beyond the Boardroom: Trust is not built in Boardrooms; it is built in the villages and areas surrounding our facilities. While India's programme operates within a robust framework of departmental, governmental oversight and regulatory scrutiny, true dialogue requires moving beyond official disclosures to grassroots engagement.

This means transforming the "Outreach Programs" from lectures and exhibitions into a forum for listening and engaging with students, researchers, faculty, local communities and press/media not just through technical reports, but through accessible, local-language communication that addresses concerns about safety and livelihood, possibilities for entrepreneurships, skill development, societal applications and benefits, research and career prospects. Transparency also means proactive crisis communication. Responses to parliamentary questions and emergency preparedness initiatives contribute to trust, but they must be matched by a willingness to engage with civil society and the media during periods of doubt. By institutionalizing this openness, we reinforce the social licence to operate.

5.3 Beyond Power: The "Silent Ambassadors" of Nuclear Science: Often, the most effective way to demystify nuclear energy is to showcase its role in saving lives rather than just powering lights. Nuclear science contributes far beyond electricity generation, serving as a silent engine of development in sectors that touch the common man daily.

Specifically, Bhabha Atomic Research Centre (BARC) and the other units of the Department of Atomic Energy (DAE) and have pioneered spin-off technologies that have revolutionized critical sectors. In agriculture, the development of high-yielding, disease-resistant crop varieties via mutation breeding has significantly boosted national food security. In healthcare, the indigenous development of the Bhabhatron telecobalt machine and the widespread availability of radiopharmaceuticals have democratized access to affordable cancer care. Furthermore, industrial applications of radioisotopes in Non-Destructive Testing (NDT) and hydrology demonstrate the versatility of nuclear science.

Communicating these benefits helps reposition nuclear science as a multidimensional enabler of development rather than a single-purpose technology. These "silent ambassadors" create a foundation of goodwill that supports the broader nuclear energy mission. In this context the Anu Yatra program at IGCAR which has been conducted across the state of Tamil Nadu and in recent years including Kerala and Karnataka is a classical example.

5.4 Institutional Commitment to Outreach: The transition from discovery to dialogue is actively being operationalized through the extensive outreach mandates of India's premier institutions. The DAE, along with its units like BARC, IGCAR, RRCAT, NFC, IPR etc has institutionalized science communication through robust public awareness programmes. By conducting science expos, student engagement initiatives, and rural development camps, these organisations are actively dismantling the 'Ivory Tower,' ensuring that the narrative of nuclear science is co-created with the society it serves.

However, this institutional effort is significantly amplified by involvement of professional bodies and science centre networks, such as the Association of Science and Technology Centers (ASTC), Indian Society for Radiation Physics etc. These bodies serve as neutral bridges between technical experts and the general public, transforming complex scientific mandates into accessible, interactive learning experiences. By fostering cross-disciplinary collaboration and providing platforms for informal science education, they ensure that the dialogue on sustainability extends beyond government laboratories into the heart of civil society.

6. Reimagining Science Communication: The Way Forward

6.1 Core Principles: Effective nuclear science communication must be grounded in scientific facts, transparency, consistency, and respect for public perception. Uncertainty should be acknowledged rather than obscured, and risks should be discussed in proportion and context.

Communication must be continuous, not episodic, and integrated into institutional culture rather than treated as an afterthought.

6.2 Institutional and Policy Measures: Dedicated science communication units within organisations, capacity building for scientists and regulators, and partnerships with educational, professional and cultural institutions can strengthen outreach. Policy frameworks should recognise communication as a strategic function essential for sustainable technology deployment. This has been well recognised fact in DAE. Apart from DAE's outreach efforts, individual units of the department have dedicated sections and scientists for this purpose.

6.3 From Acceptance to Participation: The ultimate goal is not mere public acceptance but informed public participation. When citizens understand the trade-offs, benefits, and safeguards, they can engage constructively in decision-making.

Dialogue transforms stakeholders from passive recipients into partners in sustainability.

7. Conclusion: Dialogue as the New Currency of Science

The journey from discovery to deployment is incomplete without the journey from discovery to dialogue. In an era defined by sustainability challenges, scientific knowledge must be accompanied by societal understanding and trust.

Nuclear energy, with its immense potential and complex perceptions, exemplifies the need for reimagined science communication. When communicated with clarity, simplicity and backed by rigorous scientific facts with matching analogies, nuclear science, engineering and technology would definetly get embedded in the minds of public as the nodal cornerstone of a low-carbon, sustainable future.

Scientists and engineers, organisations, science centres and professional bodies therefore, carry an additional responsibility: to advance knowledge and to engage society. Dialogue is no longer optional—it is the new currency of science in service of humanity and for better quality of life on Mother Earth.

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Discovery to Dialogue: Reimagining Science Communication for a Sustainable Future-Perspectives from Lab to Market and R&D to Commercialisation

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Introduction

India today stands at a critical juncture where scientific discovery, technological innovation, and societal aspirations converge. While our laboratories produce high-quality research and technologies, the real impact of science is realised only when these outcomes are understood, trusted, and adopted by society, industry, and policymakers.

Science communication, therefore, plays a vital role in translating discovery into dialogue. From my experience at the International Advanced Research Centre for Powder Metallurgy & New Materials (ARCI), I have observed that effective science communication acts as a silent enabler—supporting the journey from laboratory research to market relevance and societal benefit.

From Discovery to Dialogue

Traditionally, science communication was largely about dissemination—reports, publications, and technical presentations aimed at peers. Today, this is no longer sufficient. Communication must evolve into dialogue, where scientists, communicators, industry, and the public engage in a two-way exchange.

Dialogue helps:

- Build trust in scientific institutions
- Create relevance for a diverse audience
- Encourage informed and confident adoption of technologies
- Address societal concerns and expectations

When scientific concepts are communicated in accessible language without diluting their integrity, they become inclusive and impactful, fostering engagement across society. This bridges the science-society gap by making research understandable for non-specialists.

Emerging digital tools can significantly strengthen the journey from discovery to dialogue. Apart from several AI-enabled platforms, SARAL tool of Anusandhan National Research Foundation which can be used to simplify or generate layperson summaries and make research more accessible to society, National digital platforms such as Shodhganga, which provides open access to Indian research theses, and the National Digital Library of India (NDLI), which aggregates learning and knowledge resources across disciplines and languages, enhance the visibility and accessibility of scientific knowledge. Together, these Government initiatives support informed engagement by students, communicators, industry, and society, thereby strengthening the translation of R&D outcomes into societal and economic value.

Lab to Market: The Role of Communication

Focuses on moving a scientific idea or prototype out of the laboratory

Lab to Market is about bringing laboratory outcomes to the attention of industry and society—making science visible and relevant. India has a robust R&D ecosystem, yet the transition from lab to market often faces challenges—one of the reasons being communication gaps. Industry stakeholders seek clarity on

applicability, scalability, and relevance, policymakers look for alignment with national priorities, and the public seeks assurance and understanding.

Science communication can bridge these gaps by:

- Presenting technologies in problem-solution formats
- Highlighting real-world relevance
- Creating visibility through exhibitions, media, and digital platforms including short videos, podcasts, infographics, posters and presentations for wider outreach
- Supporting confidence-building among stakeholders

At ARCI, a few technologies proven at lab-scale, achieved wider recognition and reached higher TRL levels after targeted outreach—through business opportunity workshops for relevant stakeholders, technical demonstrations, and informational brochures, apart from other engagement models. This engagement not only led to collaborations with manufacturing companies for technology scale-up but also technology/know-how transfer to Indian Industries and start-ups, demonstrating how effective communication bridges the gap between innovation and real-world impact.

R&D to Commercialisation: Beyond Technology Readiness

Focuses on scaling, validation, and adoption

R&D to Commercialisation goes a step further, where technologies are scaled, validated, and adopted to create real-world value. Commercialisation is not only a technical milestone; it is also a strategic communication milestone. A technology must be seen, understood, and trusted before it is adopted. Science communicators play a crucial role in this transition by working closely with scientists to present complex ideas clearly and responsibly.

This collaborative effort ensures that:

- Scientific achievements are not isolated
- Innovations reach appropriate stakeholders
- Institutional credibility is strengthened

Effective communication supports scientists by allowing them to focus on innovation while ensuring their work reaches the right audiences.

Science Communication for Sustainability

A sustainable future requires informed decision-making by society at large. Issues related to advanced materials, energy, environment, advanced manufacturing etc., demand public understanding and participation. To enable this, science communication must be integrated with research milestones rather than treated as a post-completion activity, and embedded early in the R&D cycle to align research outcomes with societal and industrial needs. Science communication must therefore be inclusive, multilingual, ethical and context-sensitive.

By fostering dialogue rather than one-way dissemination, scientific institutions can contribute meaningfully to national missions and the vision of Viksit Bharat@2047.

Conclusions

Discovery achieves purpose only when it becomes dialogue. Science communication is not an auxiliary function—it is a strategic necessity. From laboratories to markets, from R&D to commercialisation, and from institutions to society, communication shapes how science serves humanity.

Drawing from experiences at ARCI, it is evident that when scientists and communicators work together, innovation travels farther, faster, and with greater impact—towards a sustainable and knowledge-empowered future.

Discovery to Dialogue: Reimagining Science Communication for a Sustainable Future

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Effective science communication is pivotal in bridging the divide between discovery and dialogue—transforming high-end scientific breakthroughs into societal understanding, value, and tangible impact. The journey "Discovery to Dialogue" reimagines science not as an isolated enterprise occurring behind laboratory doors, but as a shared narrative that resonates with citizens, policymakers, educators, entrepreneurs, and youth alike. In the era of Viksit Bharat @ 2047, where sustainability, equity, and resilience are national priorities, science communication becomes a strategic catalyst that connects research with everyday life, fosters scientific temper, encourages adoption of innovations, and aligns scientific enterprise with societal aspirations.

Council of Scientific & Industrial Research (CSIR), along with peer institutions and academic hubs, has catalysed this transformation through proactive outreach, inclusive engagement programmes, and innovative platforms that help demystify science and make its benefits accessible to the common man. By effectively communicating technological advancements such as sustainable infrastructure solutions, rapid healthcare diagnostics, rural livelihood technologies, and start-up technologies emerging from laboratories, these examples will be showcased during the talk to depict how science can be directly valued by society, enriching lives while accelerating national goals of sustainable development and global leadership in innovation.



The Precision Revolution: Food, Nutrition and Health as the Need of the Hour

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Opening Remarks

In 2025, the conversation around food has shifted from simple "sustenance" to "precision performance." We are living in an era where our grocery lists are influenced by AI, our metabolic health is monitored in real-time by wearable devices, and our food systems are being redesigned to mitigate the effects of a changing climate. This proceeding captures a pivotal moment in human history: the intersection of biological necessity and technological capability.

The "Need of the Hour" is not just to eat better, but to eat smarter. As we navigate a world of ultra-processed convenience and rising lifestyle diseases, the integration of modern technology offers us a way back to health—not by moving backward, but by using data to move forward.

Core Points for Better Health in the Modern Era

- Prioritize Precision over One-Size-Fits-All: The most significant shift in 2025 is Precision Nutrition. Modern technology now allows us to move past generic food pyramids. Better health requires analyzing individual "Omics"—genetic, metabolic, and microbiome data—to tailor diets that work for your specific biology.
- Embrace the "Gut-Brain Axis" for Mental Clarity: Nutrition is no longer just for the body; it's for the mind. With the rise of "Mood Foods," we must consider how our gut microbiome affects our mental health. Probiotics, prebiotics, and now post-biotics are the "need of the hour" to combat the modern stress and anxiety epidemic.
- Monitor Real-Time Metabolic Data: We can't manage what we don't measure. The use of Wearable Biometrics, such as Continuous Glucose Monitors (CGMs), has become a baseline for health. Seeing how a specific meal affects blood sugar in real-time allows for immediate behavioral changes, preventing long-term chronic diseases like Type 2 Diabetes.
- Address the "Processing Paradox": Not all processed food is "bad," but the current trend of Ultra-Processed Foods (UPFs) is a major health hurdle. The focus must shift toward "Clean Label" technology—using modern science to create convenient foods that use natural fibers and proteins instead of synthetic binders and hidden sugars.
- Focus on Nutrient Density in the GLP-1 Era: With millions of people using new metabolic medications (like Ozempic or Wegovy), the "Need of the Hour" is preventing muscle loss. The trend is moving toward high-density nutrition—foods that provide maximum vitamins and protein in smaller portions to support a changing metabolism.
- Integrate AI as a Personal Health Co-Pilot: Artificial Intelligence is the ultimate tool for health. AI-driven apps can now predict how a meal will affect your energy levels hours before you eat it. We

should consider AI not as a replacement for doctors, but as a 24/7 assistant that helps us navigate grocery stores and restaurant menus.

Sustainability & Technology: The Broader Context

- **Support Regenerative & Circular Food Systems:** Healthier soil means healthier food. We must consider Regenerative Agriculture as a health intervention. Furthermore, "Upcycling"—the tech-driven process of turning food waste (like fruit peels) into high-fiber snacks—is essential for both personal and planetary health.
- **Leverage Blockchain for Food Transparency In 2025:** "Trust is a Nutrient." Modern technology, like Blockchain, allows consumers to scan a code and see the entire history of their food. Knowing the exact origin and safety of what we eat reduces the risk of foodborne illnesses and ensures we are getting what we pay for.
- **Utilize Precision Fermentation & Alternative Proteins:** To feed a growing population without destroying the environment, we must look at tech-made proteins. Precision Fermentation allows us to create animal-free dairy and eggs that are bio-identical to the "real thing" but without the cholesterol or environmental footprint.

Closing Call to Action

- The "Need of the Hour" is a marriage between Ancient Wisdom (whole foods, mindful eating) and Modern Technology (AI, wearables, and biotechnology). If we consider these points, we don't just survive the modern world—we thrive in it.

Let us move from "Eating to Live" to "Feeding our Potential."



Science Communication - Challenges and Weaknesses

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Science coverage in the tradition media as well as the fast emerging new media—online news portals, social media channels and overall digital media, continues to fall short of the desired levels in the Indian context.

Estimates put the percentage of space allocated to science News is 3-4 percent of the total printed news. The coverage is also heavily tuned to health, strategic areas of defence, space, nuclear, agriculture, especially in a section of language media.

However, the scope and potential for growth appears immense. The digital media has completely thrown open the area of communication, writing and programming into the public domain. The era of freelancers, bloggers, citizen journalists, you tubers, podcast specialists and professionals from various fields expressing views and creating content has arrived.

These platforms offer new avenues for science communication. Simultaneously, the hunger of developments in modern science, especially the emerging areas of AI, Robotics, IoT, Cyber, biotechnology, molecular biology and genetic engineering, renewable energy and many more are exciting the public. On the other hand, scientists, who have the capability and urge to write or explain the developments now find different options to do so.

Having painted the positive picture, it remains a hard truth that most developments in these fields are taking place in developed nations. Luckily, India has a massive scientific infrastructure, 3-4th largest scientific manpower and collaborative research initiatives with advanced nations. But, there is a huge shortage of specialised science journalists, communicators and scientist-communicators at the present.

The traditional media, especially the Print, TV and Radio have been the flag bearers of reporting and analysing science and technology developments in the country and globally for decades. Many like The Hindu, Telegraph, Deccan Herald, Tribune in English continue to run a weekly science page. Similarly, Malyala Manorama, Eenadu and a few Hindi newspapers too publish a periodic science page.

For a couple of decades, science communication flourished with magazines like Science Today, Science Age, Science Reporter, Invention Intelligence, Annadata (Telugu magazine dedicated to Agriculture from Eenadu group) bringing out regular issues. The economic reforms of 1991, the growth of the IT sector gave rise to or popularised specialised magazines like Computer Today, Biospectrum magazine etc. TV and Radio had their versions of science coverage.

However, the emergence of Google and its online search after 2000 started having an impact on the printed newspapers (2000-2010). The online versions, news portals and smartphones started changing the way news was consumed, especially by the younger generation. The strong rise of social media platforms like Facebook, Twitter (now X), LinkedIn, YouTube etc have further changed the entire scenario. COVID19 was the last straw. Printed newspapers lost huge subscribers, and a small percentage returned or continue to buy.

In this changing landscape, traditional newspapers dropped science pages. News portals like Wire started their own specialised science segment. Other online portals like The Print, Scroll, Federal, First Post, News18, The News Minute etc cover lot of scientific developments as they happen and also articles by scientists. Mongabay India, exclusively covers environment, nature and wildlife. IIT Madras, boldly launched a magazine called Shastra. There are many more such examples.

The digital media—YouTube, podcast, online news portals offered scope for scientists with inclination to write or popularise science and their work to utilise. There is steady growth in this area with some scientists having their own YouTube and podcast handles.

The science communication strategy in the Union Government and some states too has undergone drastic change. In the last few years, the emphasis on return on investment and changing the focus inwards has led to some dramatic changes. The Vigyan Prasar and NCSTC have been wound up. The science communication service-India Science Wire stopped. Most of the tradition national awards have been reworked and rechristened. The Indian Science Congress, which held over 100 annual sessions has been cut to size and an alternative Science Festival is being patronised by the Union Ministry of Science & Technology. While the budgetary allocation for science departments continues to increase marginally year on year, the focus on science communication has not kept pace.

The emphasis on applied research and big support for strategic sectors is clearly the direction of the government it appears. The allocation for R&D as a percentage of the GDP remains at a low of 0.6%, though in absolute terms the amount is substantial. These developments suggest a huge shift in priorities whose merits and demerits need to be discussed and debated.

India adopted promoting Scientific Temper as part of the Constitution and a fundamental duty for every citizen. Hence, it is imperative that science communication get due recognition and coverage so that it can aid in accelerated national development. Recent history is proof, that developed nations have grown on the strength of its science and technology. India is sitting on the huge potential as it transforms into a developed nation by 2047- Viksit Bharat.



The Epistemological Silence: Reimagining Science Communication Beyond Institutional Bias

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December 2004. I stood among the wreckage of coastal Tamil Nadu, notebook in hand, bearing witness to devastation that defied vocabulary. The Indian Ocean tsunami had rewritten the geography of suffering across multiple nations. As a reporter covering Prime Minister Dr. Manmohan Singh's visit to the affected regions, I watched him articulate—with characteristic precision—the need for "more knowledgeable societies with modern scientific practices" to enhance disaster preparedness and management.

The irony was not lost on me then, though it took years to fully comprehend its implications.

While the Prime Minister's press conference emphasized technological solutions and scientific infrastructure, another narrative remained conspicuously absent from official discourse: the indigenous tribes of the Andaman Islands—the Jarawa, Onge, and Sentinelese—had survived virtually unscathed. Guided not by seismographs or early warning systems, but by ancestral knowledge of oceanic behaviour, animal patterns, and atmospheric shifts, they had moved to higher ground hours before the waves struck.

This wasn't luck. This was knowledge—epistemologically different, yet functionally effective.

The question that haunted me then, and galvanizes my argument today, is this: Why does our framework of "science communication" systematically exclude such knowledge systems from its definitional boundaries?

The Definitional Hegemony

Science communication, as currently institutionalized, operates under an unexamined premise: that "science" represents a singular, universal method of knowing, and all other knowledge systems exist either as primitive precursors or folklore requiring validation through scientific methodology. This is not neutrality—this is epistemic colonialism dressed in the rhetoric of objectivity.

My engineering education taught me the elegance of empirical methodology. My humanities training revealed how language constructs reality. My three decades in journalism exposed the political architecture beneath supposedly neutral discourse. This triangulation of perspectives compels me to argue: the crisis in science communication is not pedagogical but philosophical. We haven't failed to communicate science effectively; we've failed to interrogate what we mean by science itself.

Consider the taxonomy of knowledge embedded in our vocabulary. We speak of "scientific knowledge" versus "traditional knowledge," "evidence-based medicine" versus "alternative medicine," "modern agriculture" versus "indigenous practices." The very grammar privileges one episteme while subordinating others. The modifier "scientific" becomes synonymous with "legitimate," while "traditional" signals quaintness requiring anthropological study rather than epistemological respect.

The Engineering of Bias

My technical background allows me to appreciate scientific methodology's rigor—its reproducibility, falsifiability, and quantification. These are not trivial achievements. The periodic table, germ theory, and

quantum mechanics represent genuine expansions of human understanding. But methodology is not metaphysics. A powerful tool for certain inquiries does not constitute the totality of legitimate inquiry.

Traditional knowledge systems operate through different epistemological architectures: phenomenological observation across generations, holistic pattern recognition, and embodied wisdom transmitted through practice rather than publication. These methods lack laboratory controls but possess longitudinal depth that most scientific studies cannot match. A tribal elder's understanding of medicinal plants derives from centuries of accumulated observation—a sample size that would make any statistician envious, yet it remains dismissed as "anecdotal."

The Andaman tribes' tsunami survival exemplifies this perfectly. Their knowledge integrated multiple data streams—seismic vibrations imperceptible to human consciousness but registered through barefoot contact with earth, bird flight patterns indicating atmospheric pressure changes, receding tide patterns signalling oceanic displacement. This represents systems thinking of profound sophistication, yet because it lacks peer-reviewed publications and controlled experiments, institutional science communication treats it as fortunate superstition rather than legitimate meteorological knowledge.

The Literary Dimension of Truth

As someone who has authored poetry anthologies and critical works exploring metaphysical and ontological dimensions of human experience, I recognize that some truths resist propositional encoding. The scientific paper—with its abstract, methodology, results, and discussion—brilliantly captures certain knowledge but systematically excludes others.

How does one peer-review the accumulated wisdom of forest-dwelling communities about ecosystem dynamics? How does one create a control group for knowledge embedded in seasonal rituals refined over millennia? The inability to translate such knowledge into scientific format doesn't invalidate it—it reveals the limitations of that format.

My literary work has taught me that metaphor, narrative, and embodied experience constitute legitimate modes of knowing. A poet understands storm systems through different instruments than a meteorologist, yet both understandings possess validity within their domains. Science communication's insistence on singular epistemological validity represents intellectual impoverishment masquerading as rigor.

The Institutional Architecture of Exclusion

Current science communication operates through institutional structures—universities, research journals, funding agencies, government science departments—that inherently privilege credentialed knowledge producers. This creates a self-reinforcing system where "communicating science" means translating laboratory findings to lay audiences, never questioning whether the laboratory represents the sole legitimate site of knowledge production.

The National Tuberculosis Elimination Programme, advanced genomics research, space exploration—these represent magnificent achievements of institutional science. But when science communication becomes exclusively about such achievements, it implicitly delegitimizes other knowledge traditions. The message received by the public is clear: legitimate knowledge requires white coats, institutional affiliation, and publication in indexed journals.

This bias has civilizational consequences. When agricultural extension services promote chemical fertilizers while dismissing traditional soil enrichment practices as "unscientific," they don't merely communicate science—they enforce epistemological hierarchy. When urban planners ignore indigenous water harvesting systems in favour of "modern" infrastructure, they demonstrate that science communication functions as cultural homogenization

The Dialogic Imperative

My argument is not anti-science but pro-plurality. I am not suggesting we abandon empirical methodology or peer review. I am insisting that science communication, particularly in the context of "Viksit Bharat 2047," must expand its definitional boundaries to accommodate epistemological diversity.

This requires concrete transformations:

First, science communication must acknowledge its epistemic biases explicitly. Current frameworks pretend to neutral objectivity while enforcing particular knowledge hierarchies. Intellectual honesty demands we name this.

Second, platforms must be created where different knowledge systems engage as equals rather than superior explaining to inferior. When ICMR nutritionists dialogue with traditional healers about metabolic health, both parties should be recognized as knowledge holders, not one as scientist and the other as informant.

Third, validation frameworks must expand beyond reproducibility and quantification. Longitudinal observation, holistic pattern recognition, and phenomenological depth represent legitimate epistemological methods deserving institutional recognition.

Fourth, science communicators themselves must possess multilingual epistemological fluency—the ability to translate between knowledge systems without privileging one as foundational.

The Sustainable Future Demands Epistemic Justice

The panel discussion theme—"Discovery to Dialogue: Reimagining Science Communication for a Sustainable Future"—contains profound wisdom if we read it carefully. "Discovery" assumes knowledge emerges from investigation. But what of knowledge that exists already, embedded in communities, transmitted through generations, waiting not for discovery but for respectful engagement?

"Dialogue" implies multiple voices. Yet current science communication structures operate as monologues—institutional science speaking to passive publics. Genuine dialogue requires recognizing that the tribal elder, the traditional birth attendant, the organic farmer possess knowledge rather than mere beliefs requiring correction.

"Sustainable Future" cannot be built through epistemological monoculture. The climate crisis, biodiversity loss, and ecological disruption stem partly from privileging extractive, reductionist knowledge systems while marginalizing holistic, reciprocal ones. Indigenous communities maintained ecological balance for millennia not through ignorance but through sophisticated knowledge systems that understood humans as participants in rather than masters of nature.

Toward Epistemological Democracy

My journey—from engineering to humanities to journalism to literary criticism—has been a progressive expansion of what constitutes legitimate knowing. Each discipline revealed limitations in others, not through negation but through complementarity. The engineer's precision, the humanist's interpretive depth, the journalist's empirical groundedness, the poet's metaphorical insight—all represent valid epistemological instruments.

Science communication for Viksit Bharat 2047 must embrace similar pluralism. This doesn't diminish science—it democratizes it. It recognizes that the laboratory and the forest, the research paper and the oral tradition, the controlled experiment and the generational observation each illuminate reality from distinct vantage points.

The 2004 tsunami taught us—though we have been slow to learn—that survival sometimes depends on knowledge excluded from institutional frameworks. The Andaman tribes possessed no doctoral degrees, published no papers, received no research grants. Yet their knowledge saved lives while modern infrastructure failed.

Science communication's responsibility shifts from "championing one knowledge system" to "creating platforms where epistemologies dialogue." This doesn't diminish science—it democratizes it.

The question before this conclave is whether we possess the intellectual courage to acknowledge that "Lab to Society" might need reframing as "Labs and Communities to Collective Wisdom"—a grammar that recognizes multiple legitimate sites of knowledge production rather than assuming unidirectional transfer from credentialed experts to ignorant masses.

The sustainable future demands nothing less than epistemological justice. Science communication must lead this transformation or risk irrelevance in a world increasingly recognizing that no single knowledge system holds monopoly on truth.





INVITED ARTICLES FROM EXPERTS



Scientific Temper: The Greatest Gift of Science Communication

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The Scientific Temper Matters..

Every action of our daily routines today is a testimony of the innate scientific temper of human beings over millions of years. The clocks that we look at to check the time, the clothes that we wear, the vehicle that we use to get to work, … the work that we do …

The journey of human evolution, over millions of years, sprung from acts of observation. Observations which may have been vacuous at first, which then, after being made repeatedly, led to recognition of patterns. Changes of the seasons with corresponding changes in food and water scarcity or excess, corresponding changes in temperatures leading to needs for shelter ……. The initial reactions rose from the reflexes of self protection. But after many cycles of similar changes, human beings learnt to connect the dots! They learnt to anticipate what was going to happen, in advance, and prepare for it. This was the birth of reason.

Although there were times when reason failed and gave wrong answers, human beings learned further from these failures about the boundaries, wherein reasoning worked best. With this approach, fire was tamed for gainful use, use of medicines to preserve health was discovered. To wish to know and understand, to be ready to learn through application of methodical observations and logical deductions is a fundamental trait of being human, driven by the basic characteristic of the scientific temper. This characteristic, stemming from the awareness that the natural world around us can be analysed, learnt from and subsequently influenced, sets human beings apart from all species that came before it. Archeological findings in many parts of the world, made over years till today, bears witness to the changing relationships between humans and their natural environments.

Despite the advantages of the scientific temper, there were many humans who resisted it, because, in its quest to find the truth, scientific temper demands courage and humility! The courage to recognize and accept a truth even when it is unfavorable, humility to admit being wrong, when evidence to the contrary makes earlier reasonings questionable. Fast forward to the last few thousands of years of human civilization. The origin of the scientific temper and of science itself is attributed to the Greeks. From Thales, through Anaximander and Anaximenes, through Socrates, Plato and Aristotle, they upheld the belief that 'an unexamined life is not worth living'! They not only developed a documented system of deductive reasoning of observations of the natural world, they also grew a culture of "how do we know what we know?" In India too, texts written thousands of years ago, propounded that to establish something as a fact, one has to go through the following stages: Pratyaksha (Perception); Anumana (Inference); Upamana (Comparison); and Shabda or Aptavakya (Testimony). Gautama Buddha had said, "Do not take the authority of the teacher or the text. Always, question yourself." He had stressed the importance of seeking empirical evidence.

Scientific temper as a notion has existed for a long time; the terminology became frequently used in the mid-19th century. In a lecture in 1922, Bertrand Russell used the example of Albert Einstein' theory of relativity to explain the meaning of scientific temper. When predictions of the Sun's effect on the bending of star light made, based on Einstein's theory of relativity, were verified during the eclipse of 1919, the whole theoretical framework of traditional physics was upset. Yet physicists exhibited scientific temper and accepted his theory when evidence appeared in its favour. At the same time, they, including Einstein himself, were aware that there are difficulties that his theory did not explain; that one day his doctrines will have to be modified in their turn, as they have modified Newton's.

The scientific temperament of adopting a rational, questioning, and evidence-based approach to life, using logic and observation to form beliefs and being open to changing views when presented with new facts, is enshrined in the Constitution of our country in the forty-second amendment in 1976, Article 51 A(h) under the Fundamental Duties that states:

[It shall be the duty of every citizen of India] To develop scientific temper, humanism and the spirit of inquiry and reform.

Thus, the value of scientific temper was already recognized as essential for the advancement and well being of the people of the country, on the paths of pursuance and growth of science and technology. From that time till present, systematic setting up of scientific infrastructure like DST, CSIR, IITs, Atomic Energy Commission, ISRO, and strengthening research which brought the Green Revolution, the White Revolution. In the last decade the jump to include private sector involvement in research and technology was propelled through setting up of Technology Parks in many cities (Nanotechnology, Biotechnology, Renewable Energy, among others). The National Quantum Mission, the IndiaAI Mission are designed to put India on the frontiers of technological advances, globally.

The scientific temper, however, is not only about excellence, but also about equity, ethics and cooperation. It is a civil virtue which has the capability to transform society as a whole. A scientific temper empowers individuals to make informed decisions, solve problems, and resist unsubstantiated claims, leading to intellectual maturity with humility and an inclusive open-minded society, which admits achievements and failures, without fear or favor.

Why is Scientific Temper hard?

The core of Scientific Temper, rational thinking, has waxed and waned in civilizations, over the world, throughout different times. In Indian kingdoms, from several hundred years BCE, many rulers recognized the value of the scientific temper for the growth of society and fostered a pragmatic and philosophical approach to life, driven by practical needs and existential questions, evident from metallurgy to cosmology.

Though such an approach has inevitably led to prosperity and progress, the scientific temper has been hard to maintain and promulgate. Societies have alternately ridden on the crests and troughs of scientific attitude and its outcomes. Even today, after an evolutionary history of millions of years, when sections of humankind are looking to colonize space, other sections grapple with complete refusal to recognize the scientific temper, due to

- **Conflict with Deeply Rooted Beliefs:** being open to change conclusions in the face of new evidence, often clashes with traditional beliefs of perpetual and unchanging Truth.
- **Cognitive Biases and the Need for Certitude:** a deep preference for definitive answers finds the constant uncertainty of science psychologically challenging to accept.
- **Influence of Pseudoscience and Misinformation:** a propensity to accept sensationalized or emotionally appealing misinformation, in the face of areduous fact-checking and critical evaluation efforts.

- **Deficiencies in Education Systems:** a focus on rote memorization of facts rather than teaching the scientific method, producing individuals with science degrees , but lacking scientific temper.
- **Social and Political Factors:** influence of powerful personalities, who may endorse an unscientific or irrational idea, which obscure the distinction between fact and myth.
- **Lack of an Enabling Environment:** being deprived of an environment that supports curiosity, open-mindedness, and the right to question, without fear of repercussions.

Within individuals and societies, rationality has clashed with emotional presence and identity. Rationality has also conflicted with individual and collective self preservation instincts, which are inherently based on reactions to triggers of fear.

It is here that Science Communication can create bridges!

The Rise of Science Communication

When scientific investigations were in their nascent stage, discussions of the ideas and results were shared through lectures, books, and societies, within elite circles of fellow practitioners. Starting from the 19th century, some reformers used science to promote social change and economic progress. However, the gap between the practitioners of science and the 'others' continued to be a wide and deep one, with the strongly prevalent idea that scientific pursuits are not meant for all.

Science communication was experimented with, by an emerging class of scientists, who could sense its power in influencing and opening up young minds to the vastness of exciting possibilities in the physical and socio-economic world. Notable figures are Carl Sagan, Jane Marcet, John Dewey, Swami Vivekananda, John Durant, Goeffrey Thomas and others. Peoples' Science Movements were started in India in the 1960s, which organized processions that travelled from village to village, using theatre, songs and puppet shows to communicate science-related information on health, water production, and disaster prevention to the masses. In the 20th century, the Space Age appealed to the imagination of large number people and interest and spread of information intensified. Lectures and TV programs became more and more prevalent, firing large number of young minds to pursue new discoveries and inventions. Works of science fiction, basing itself on scientific principles and using imaginations of advanced scientific and technological progress, eg. Frankenstein, Twenty thousand leagues under the Sea, Foundation series and Star Wars, 2001: A space Odyssey and many others never fail to capture the attention of young and old.

During the mid 1900s, science communication began to be recognized as a formal field, growing into a vital, interdisciplinary practice addressing public understanding, policy, and global challenges. Public engagement, allowing public participation in research, became increasingly possible. Recent years have seen a huge drive to bring science and research, data, methods and results, to a wider audience. Science is no longer the bastion of the wealthy, well-educated man, but belongs to all of us. The benefits of spread of science and technology in powering nations to grow economically, transformed the public sphere and incentivized large numbers of people to navigate an S&T-driven world. This kick-started campaigns to get people into STEM, to educate and inform, and to generally fill the knowledge deficit that the public outside the scientific community was perceived to have. As the influence of scientific information came closer and closer to lives of individuals, the engagement became tighter, with contextual, engaging, and comprehensive access to facts and research that will impact lives of individuals – in health, technological and climate science frontiers – so that persons are able to make their own decisions and demand their leaders make decisions in their best interest.

The arrival of the internet and social media, along with high quality videography and animations, visual forms of communication are an increasingly popular tool for communicating all manner of subjects. On an average day, 9 billion videos will be viewed on Facebook and YouTube alone. Podcasts have also seen exponential growth over the last decade, with science becoming a mass-appealing genre. Scientists

themselves participate in them, garnering digital followings and giving science a face. Effective science communication means the public can be informed, entertained, and empowered by learning science, and researchers can see their work move and influence society. It is this mutual connection that has the potential to be transformative for science and global communities.

The Science Communication Imperative

Contrary to initial perceptions about the value and authenticity of science communications, it is recognized today that it is not a diminutive or distorted form of science but rather the sum of social conversations around science. In today's realm of explosion of information, largely in near real time, the scope and responsibility of science communication is many folds. With information dissemination made easy, the proportion of unverified or simply made up information, which is available at any instant is unimaginably large, with the potential to seriously influence thousands of people.

Along with bridging research/practice gaps, educating non-specialists, creating informed user base and developing evidence-based public opinion, addressing misinformation has become a major responsibility of science communicators. This can happen when large number of scientists themselves engage in these efforts.

Beyond this, science communication must make specialized efforts to nurture the scientific temper of our social fabric. It must strive to reconcile rationality and emotional health of individuals and communities by spreading scientific ideas and developments, while including constructive discussions on the corresponding unverified claims and prevalent pseudo-scientific concepts. This approach has to accept both rationality and emotional vulnerability as partners, contextualize and balance them with logic, self-awareness as well as humane understanding. This may ultimately allow people to imbibe scientific temper, leading to wiser choices, keeping their own as well as community interests in view and generate over-all well being.

Our country has always been very much in favor of scientific temper and innovation. But does our society cheer the proponents of skepticism, champion the ones whose constructive efforts led to failures, applaud critical minds, make evidence-based decision-making a mandate, reject irrational beliefs? Such dichotomies, if they exist, indicate a disjuncture between the ideal and the on-ground reality, which is the onus of science communication to eradicate!

The future of India does not rely merely on the excellence of research-development-innovation, but on how rational inquiry becomes the backbone of all productive activities at individual, societal and national levels.



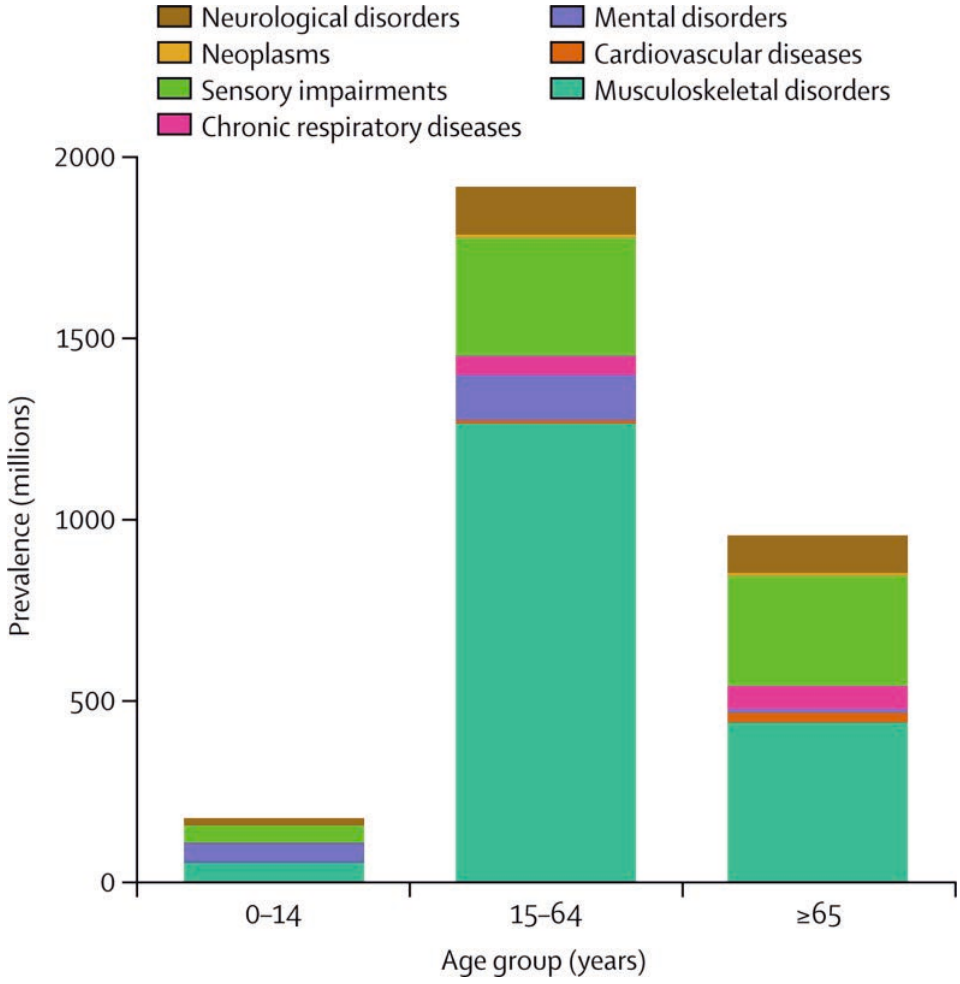
Stronger Bones, Stronger Body: A Guide to Lifelong Musculoskeletal Health

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As we age, our bodies undergo a quiet but significant transformation. While we often focus on heart health or brain power, there is an invisible foundation supporting everything we do: our musculoskeletal system. Comprising our bones, muscles, and joints, this system is what allows us to move, work, and stay independent.



The most frequent disorder in the population at any age and particularly in the middle years and old age are Musculo Skeletal disorders. While Sarcopenia is decrease in muscle volume Osteopenia is a decrease in bone volume with the insides of the bone still being intact. On the other hand, Osteoporosis is a decrease in bone volume associated with damages inside the bone microstructure and has the highest risk of fracture even with trivial injury.

Conditions like osteoporosis (thinning bones) and sarcopenia (loss of muscle mass) often develop without symptoms until a fall or fracture occurs. The good news is that through early intervention, proper nutrition, and the right kind of movement, you can protect your "bone-muscle unit" for years to come.



Women particularly in post-menopausal years are at greatest risk of osteoporosis and heightened fracture risk. Bone mineral density tests should be done at regular intervals and if values are below 2 SD of the mean score, urgent interventions are required. Bone minerals or calcium gets accrued in the bone during adolescence. After 30 yrs of age there is only a loss of calcium and bone. The best approach is to provide healthy and bone strengthening diets during the younger years.

The Bone-Muscle Connection: A Two-Way Street

Our bones and muscles aren't just neighbours; they are a functional team. When muscles contract, they exert a mechanical load on our bones, which sends signals to our body to keep repairing and strengthening them. This relationship begins before birth and remains vital throughout our entire lives.

When we become less active—whether due to aging or chronic disease—a downward spiral can begin:

Muscle loss (Sarcopenia): Decreased use leads to weaker muscles.

Bone thinning (Osteoporosis): Without the pull of strong muscles, bone density drops.

Joint wear and tear: Weak muscles lead to poor weight-bearing, causing joints to degenerate (Osteoarthritis).

The Result: Pain, weakness, and a much higher risk of fractures even from minor trauma.

In India, this is a particular challenge. Studies show that bone mineral density (BMD) scores in healthy Indians are often lower than western standards, making early prevention even more critical.

Nutrition: Beyond Just Drinking Milk

While calcium is famous for bone health, it is only one piece of the puzzle. A "whole foods" approach is the most effective way to fuel your musculoskeletal system.

Protein is key: Protein isn't just for bodybuilders; it is essential for maintaining muscle mass (preventing sarcopenia) and bone structure.

The power of Vitamin D: Often called the "sunshine vitamin," Vitamin D is essential for calcium absorption. In India alone, an estimated 490 million people are deficient. While supplements can help if you are truly deficient, they are most effective when combined with calcium.

The "Prudent" Diet: Research shows that a "healthy/prudent" diet—one rich in vegetables, fruits, and whole grains—is linked to a lower risk of low bone density and fractures. Conversely, "Western" diets high in processed meats, soft drinks, and fried foods are associated with a higher risk of osteoporosis.

A Note for Vegetarians: Some studies suggest that strict vegetarians and vegans may have a higher risk of hip fractures, likely due to lower intakes of certain minerals and protein. If you follow a plant-based diet, it is important to be intentional about getting enough calcium, Vitamin D, and protein.

Movement: The Best "Medicine" for Your Joints

If you want to keep your bones and muscles strong, not all exercise is created equal. While walking is great for heart health, resistance training and weight-bearing exercises are the gold standards for bone health.

Strength Training: Lifting weights or using resistance bands helps improve grip strength and lower-body muscle mass.

Impact Exercises: High-intensity progressive resistance training has been shown to be more effective at improving bone density in the spine than low-intensity home programs.

Multicomponent Training: For older adults, combining strength, balance, and flexibility exercises can significantly reduce the risk of falls and improve functional mobility.

Take Charge Today

Musculoskeletal health is a lifelong requirement. Whether you are in your 20s or your 70s, it is never too late to start:

Check your levels: Talk to a doctor about your Vitamin D and Calcium intake.

Eat for your bones: Prioritize protein and a balanced, whole-food diet.

Get moving: Incorporate some form of resistance or weight-bearing exercise at least twice a week.

By treating your bones and muscles as a single, vital unit, you aren't just preventing a fracture—you are investing in your future independence and quality of life.



Soybean for Everyday Nutrition: A Smart Choice for Health and Vitality

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Soybean is one of the very few plants that provide a high quality protein with minimum saturated fat. Soybeans help people feel better and live longer with an enhanced quality of life. Soybeans contain all three macronutrients required for good nutrition, as well as fiber, vitamins and minerals. Soybean protein provides all the essential amino acids in the amounts needed for human health. Almost 40% of the calories from soybeans are derived from protein, making soybeans higher in protein than any other legumes and many animal products. Health professionals consider soy protein as superior protein. The amino acid pattern of soy protein is virtually equivalent in quality to that of milk and egg protein. The 1990's FAO/WHO protein evaluation committee put soy protein at par with egg and milk protein and ahead of beef protein. Unlike many other good sources of protein, soybeans not only have higher percentage of oil but also quality fatty acid profile. It has low saturated fat content with high amount of PUFA and is readily available source of essential fatty acids. Soybean oil is also rich in omega-3 and 6 fatty acids like those found in fish oils and cholesterol-free. Soybeans, especially the outer hull, are an excellent source of dietary fiber. Soybean has more than two times the amount of most minerals, especially calcium, iron, phosphorus and zinc, than any other legume and very low sodium content. Soybean has all the important vitamins and is very good source for Vitamin C and Vitamin E.

Soy Protein Quality

PDCAAS of Food Proteins	
Soy Protein	1.00
Casein and Whey	1.00
Egg white	1.00
Beef Protein	0.92
Pea Protein	0.73
Peanut meal	0.52
Rice	0.47
Corn	0.42
Whole Wheat	0.40
Wheat Gluten	0.25

Soy protein has good amino acid profile and also has a number of health and functional benefits. Earlier it was perceived that soy protein is deficient in Sulphur containing amino acids but with the new method of evaluation (PDCAAS), it has been proved that soy protein has all the essential amino acids. Based on this new FAO/WHO approved method soy protein quality is at par with milk and egg. Soy protein is one of the cheapest sources of protein available for mankind. Cost of soy protein is less than half of wheat protein and almost six times cheaper than egg.

Health Befits of Soybean

In addition to being a rich source of nutrients, soybeans have a number of phytochemicals (isoflavones), which offer health benefits along with soy protein though they do not have any nutritional benefits. Soy protein and isoflavones together contribute to several health benefits such as cholesterol reduction, cancer prevention, combating osteoporosis, diabetes management and menopause regulation, etc.

Soybeans contain both soluble and insoluble fiber. Soluble fiber may help lower serum cholesterol and control blood sugar. Insoluble fiber increases stool bulk may prevent colon cancer and can help relieve symptoms of some digestive disorders. Human epidemiological studies suggest that as little as one serving of soy foods each day may be protective against many types of cancer.

Soy protein has two different benefits in the food products. One, the health benefits of soy protein plays a major role in functional (health) foods. With on-going scientific evidence on the health benefits of soy

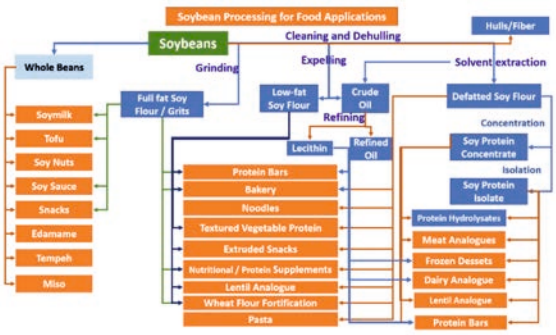
protein in reducing the burden of degenerative diseases, soy is becoming a main ingredient in these functional foods. With the sophisticated soy processing technologies, these protein ingredients are becoming palatable and more acceptable in this category of foods. As far as a food processing industry is concerned functional properties mean any food ingredient that performs certain function during food processing. The functionality that comes to one's mind is texture of bread or cake or overrun in ice cream. In the food ingredients, protein is considered to possess number of functional characteristics due to its (tertiary) structure.

Soy Protein Structure and functions

Except for their nutritional applications and before the revelation of the health benefits, soy protein products have been used primarily for their functional characteristics. Based on the protein structure and arrangement of amino acids, soy protein provides certain functional properties in food processing such as, low fat binding capacity (FBC), high water absorption capacity (WAC), emulsification property, whipping characteristics etc. This varying FBC and WBC are due to the arrangement of polar and non-polar amino acids in the structure of protein. Native soy protein has polar bonds (hydrophilic) amino acids outside and non-polar (hydrophobic) amino acids inside. The presence of both hydrophilic and hydrophobic groups in the same polymer chain facilitates association of the protein with both fat and water. The protein may adhere to solid particles and act as a binder or, in solution, as a dispersing and suspending agent. Protein films may adhere to surfaces, and solids may be distributed and cemented together within the protein film. Such properties usually require a protein with a relatively high degree of water dispersibility, soluble proteins are easier to incorporate into moist foods. In a relatively insoluble protein product, these properties are present to a limited degree. Although such products remain highly valuable nutritionally, they may contribute only slightly to viscosity, gel formation, emulsification, binding, adhesion, or to the stabilization of emulsions and suspensions. When soy protein is given heat treatment, the native structure gets denatured so these functional benefits will be lost. In order to achieve the full potential of soy protein functionality, the processor has to maintain highest possible protein dispersibility index (PDI). Most of these functions of soy protein can be achieved if the PDI of soy flour is above 70 but higher the better.

Soybean Processing for Food Applications

Soybean is a highly versatile legume that can be processed into number of derivatives as food ingredients. Advanced processing technologies preserve the functional characteristics of protein and other components. Some of the functional derivatives of importance in the food industry are Full fat Soy Flour, Low-fat Soy Flour, Lecithin, Defatted Soy Flour, Soy Protein Concentrate and Soy Protein Isolate



Benefits of Soy Derivatives in Food Industry

In addition to the health and nutritional benefits, soy protein derivatives have number of functional advantages in processed foods. The following illustration shows the advantages of soy derivatives in different food processing sectors based their functional attributes.

- Bakery - Improve product quality, Reduce costs, Reduce wastage
- Beverages - Stability
- Process meats - Improves texture, Reduce wastage, Economical
- Dairy analogues - Economical
- Frozen desserts - Increases overrun, Economical
- Dressings and Spreads - Economical

- Protein supplements - Stability, Economical & Disease specific
- Sports nutrition - Economical

Functions of Soy Protein in Meat-based Product

One of the universally recognized and most acceptable functional applications for soy derivatives is processed meat industry. In addition to improving nutritional value and antioxidant properties, soy derivatives improve uniform emulsion formation and stabilization, improves firmness, pliability and texture through gelation. Soy derivatives reduce cooking shrinkage and drop by entrapping-binding fats and water, preventing fat separation and enhance binding of meat particles without stickiness. The functional attributes of soy derivatives improve moisture holding thus improve mouthfeel and facilitates cleaner, smoother slicing. Functionality of soy derivatives not only improve the product texture and quality but also provide economic Benefits and improve processing efficiencies by providing higher processing yields, cook yields and ability to rework. The table below illustrates benefits of soy protein in different meat products

Emulsified Meats	Coarse Ground Meats	Whole Muscle Meats	Seafood & Surimi-Based Products	Meat Analogs Key Benefits
Reduce Waste Maximize Yields Replace Meat Improve Texture Aid Processing Reduce Formulation Costs	Moisture Retention Increase Yields Emulsification and Fat Binding Enhance Texture Improve Machinability Improve Costs	Enhance Texture Maintain Firmness Improve Slicing Increase Marinade Performance Reduce Cost by Improving Yield Minimize Purge and Weeping	Maintain Fresh Fish Texture Reduce Water Loss Improve Firmness Add Value to Trim	Wide Variety of Textures, Colors and Shapes Meet Vegan and Vegetarian Requirements Kosher and Halal

Soy Protein derivatives in beverages

Soy derivatives, especially protein, plays a very important role in beverages. Typically, beverages have about 90% water so the protein's ability to interact with water and other ingredients determines the beverage properties and its stability. Protein can greatly affect the overall properties of the beverage, including viscosity, mouthfeel, stability, flavor, and appearance. The relationship between physical properties of proteins and beverages as illustrated in the table.

Solubility	Appearance, mouthfeel, sediment, suspension stability
Emulsification	Suspension stability, mouthfeel, appearance, color
Viscosity	Mouthfeel, stability, flavor
Flavor binding	Flavor
Particle size	Mouthfeel, color, and appearance
Heat stability	Color, suspension

Selected Functional Characteristics of Soy Protein in Baking Systems

Functional property	Mode of action	Baking system	Protein form
Emulsification			
Formation	Formation and stabilization of fat emulsions	Breads, cakes	Flour, SPC, ISP
Fat Adsorption			
Prevention	Binding of free fat	Doughnuts, pancakes	Flour, SPC
Water Absorption and Binding			
Uptake Retention	Hydrogen bonding of water, entrapment of water, no drip	Breads, cakes	Flour, SPC
Dough formation	-	Breads, cakes	Flour, SPC, ISP
Cohesion-adhesion	Protein acts as adhesive material	Breads, cakes	Flour, SPC, ISP
Elasticity	Disulphide links in deformable gels	Breads, cakes	Flour, SPC, ISP
Flavour-binding	Adsorption, entrapment, release	Breads, cakes	SPC, ISP, hydrolysates
Foaming	Forms stable films to trap gas	Whipped toppings, chiffon desserts, angel cakes	ISP, soy whey, hydrolysates
Colour control			
Bleaching	Bleaching of lipoxygenase	Breads	FFS
Browning	Maillard, caramelization	Breads, pancakes, waffles	All protein derivatives

The Beneficial Role of Soy in Bakery Products

Soy derivatives, especially, soy flour, has consistently proved economic benefits both in the laboratory and in a commercial bakery setting. In addition to providing functional benefits in the bakery products, soy flour has excellent nutritional profile. Even at 3% inclusion rate, soy flour provides significant contribution of superior quality protein in the finished product.

Functional soy flour will work perfectly for any bakery products and provide following benefits.

- Increases yield: The unique functional characteristics of the protein will enable hold more moisture during the dough development process, which would result in increased yield in bread.
- Reduces bake loss: The protein component of soy flour holds the water tightly and reduces water evaporation during baking. This would result in reduced bake loss.
- Increase shelf life: The additional water held by the bread would be tightly bound and would not be available for the microbes to grow during product life. The bound water will help in keeping the product softer for longer time. This would reduce the staling of bread and increase the of the shelf of the product by about 24 to 36 hours. This attribute of the ingredient would reduce bread returns from the market.
- Reduction of oil absorption: in deep fried products such as donuts soy flour will help in about 20% reduction in oil absorption.

Product	Replacement (%)	Benefits		Soy Component
		Functional	Economic	
Cake	Egg (60-100)		Yes	Flour, Isolate, Lecithin
Bread	White flour (1-5%)	↑ yield & shelf life	Yes	Flour
Cookies	SMP (60-100)		Yes	Flour, Isolate
Doughnuts	White flour (5-10%)	↓oil absorption	Yes	Flour
Noodles	White flour (10-15) and eggs (60-100)	↑ yield, ↓oil absorption	Yes	Flour

Also, soy flour will help in reducing production costs by replacement of Expensive ingredients.

Eggs can be fully or partially replaced using lecithinated defatted soy flour. Studies at AIB demonstrated that about 25% of the raw material cost can be reduced using lecithinated soy flour.

Defatted soy flour along with sweet dry whey can completely replace skim milk powder, which is an expensive ingredient in food and bakery industry. Enzyme treated soy protein isolate can replace egg white in the bakery and food industry.

Lecithin



Soybean lecithin is a complex mixture of phospholipids, glycolipids, triglycerides, sterols and small quantities of fatty acids, carbohydrates and sphingolipids. Soy Lecithin Powder is partially water-soluble, an emulsifying agent that helps fat and water stay together. Therefore, it is often added to foods, such as chocolate, cheese, margarine, and salad dressing. It has health benefits such as reducing cholesterol level. Soy lecithin has natural phospholipids from soybeans. Soy lecithin offers a multifunctional, flexible and versatile tool. It is probably best known for its emulsifying properties, which help promote solidity in margarine and give consistent texture to dressings and other creamy products.

Lecithin is also used in chocolates and coatings and to counteract spattering during frying. Additionally, its unique lipid molecular structure makes lecithin useful for pharmaceutical and cosmetic applications and various industrial uses such as paints, textiles, lubricants and waxes.

Functionality of Lecithin	Uses of Lecithin in Processed Foods
• Disperse and suspend powders into liquids • Control the viscosity of liquids and semi-liquids • Viscosity reduction of chocolate and compound coatings. • Prevent foods from sticking to contact surfaces • Prevent adhesion of food products to one another • Alteration of fat crystal size and structure. • Texture, chewiness and mouth feel improvement of fat-containing centers. • mproved mechanical characteristics such as cutting, extruding and forming	• Baked Goods • Dairy Products • Chocolate • Cocoa Powder • Chewing Gum • Caramels & Toffees • Hard Candies • High Protein Beverages • Powdered Chocolate Beverages • Gravies, Instant Foods, Prepared Foods
	Health Benefits of Lecithin
	• Vascular health/cholesterol transport • Reduce absorption of cholesterol by intestine • Improve Liver Function • Memory Enhancement • Aiding in Child Development

Soy Fiber

Soy fibre is another excellent functional ingredients from soybean, which has a number of health benefits. Soy fibre also has a functional benefits in the food processing system and can play a significant role in developing healthy and functional food products. Soy fiber are processed using advanced technologies has great applications in the Indian food and health food industry. There are two types of soy fiber available for food applications. Soy fiber that comes from hulls and fiber from soy cotyledons. Soy fiber that comes from hulls is sometime called as soy bran, which can be used breads, cereal and snacks to enhance insoluble fiber. Soy fiber from soy cotyledons has both soluble and insoluble fiber, which is similar to okara. Soy fibre has neutral bland flavor, it can be successfully combined with different flavours and can be used as a substitute for groundnuts, almonds, marzipan and as a filling for cookies and chocolates. Soy fiber can be used as additive in biscuits and snacks as it reduces calorie intake and increase dietary fiber. This can be effectively used in meat analogues to improve texture and water holding capacity. Soy fiber can be used extruded to obtain "puffed structures which can be used to formulate healthier snacks and cereals. Soy fiber in liquid products such as creamy soups resulting in improved fullness and creaminess sensation while providing dietary fiber.

Functional Benefits of soy Fiber

- Yield Extension
- Shelf Life Extension (Control water activity)
- Improved Structure / Texture
- Improved Flavor / Moisture
- Enhanced Microwave-ability
- Enhanced Freeze / Thaw Stability
- Fat Replacement
- Reduces stickiness
- Reduces cracking and hardening in flat breads

Strategy to Formulate a Food Product with Soy

Decide what level of soy is needed?

Are you trying to make a health or label claim?

What are the cost implications of the chosen soy derivative?

What is your marketing message?

What are the nutritional requirements the products needs to meet?

Make taste your most important criteria!

How Does Soy Protein Fare With Other Sources?

As discussed above protein plays an important role in food processing industry. An ideal protein as a food ingredient not only should have functionality but also should have the attributes like economical, stable pricing, protein quality, nutritional quality, safety and availability.

Soy Protein is the most economical protein, which is highly cost effective with most stable pricing and very high protein density. Also, soy protein provides excellent Functional Properties in the food systems, which may also help in full or partial replacement of expensive functional ingredients with superior nutritional quality.

	SOY	MILK	Egg	Meat
Protein Quality	✓	✓	✓	✓
Supported by FDA Health Claim	✓			
Benefits in weight management	✓	✓		
Bioactive Components	✓	✓		
Proven Health benefits	✓	✓		
Protein Density	✓			✓
Safety	✓	✓	✓	✓
Functional Properties	✓	✓	✓	
Economics	✓		✓	
Availability	✓	✓	✓	✓
Score	**10/10**	**7/10**	**5/10**	**4/10**

Conclusion

Based on the protein structure and arrangement of amino acids, soy protein provides certain functional properties in food processing such as, low fat binding capacity, high water absorption capacity, emulsification property, whipping characteristics etc. There is dramatic increase in the demand for processed and convenience food in the global populations. Given these two factors soy and soy ingredients have immense potential in the food processing industry. Soy is a highly versatile legume that can be processed into number of derivatives as food ingredients. With the sophisticated soy processing technologies, these protein ingredients are becoming palatable and more acceptable in this category of foods. These functionally active soy ingredients provide functional benefits in the food processing systems such as producing vegan/vegetarian products (dairy & meat analogs) replacing expensive ingredients, improving process efficiencies, etc. Also, based on various characteristics of soy protein, it can be considered as the ideal protein for food systems. Indian Soy processor may upgrade their existing facilities to produce functionally active defatted soy flour and other value-added products to provide ingredients for the food industry. These functionally active value-added products also provide export opportunities for Indian soy products.



Oils & Fats for Health and Nutrition

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Importance of Oils and Fats in our Diet: Healthy diet consists of three major macro nutrients namely proteins, carbohydrates and oils & fats. Oil and fats are very important for the maintenance of good health. In case of less consumption of oils and fats may lead to retarded growth, skin lesions, kidney and liver disorders etc. Hence, oils and fats are very important ingredients of our diet for nutrition and health and do not blame or reduce the consumption of oils and fats too much after seeing some unscientific viral videos. Oils and fats provide precursors needed for making biological membranes such as phospholipids and cholesterol vital for making the cell membranes. Oils and fats provide essential fatty acids which are the precursors for the synthesis of prostaglandins, thromboxane, leukotrienes, lipoxin, resolvins etc. which are the building blocks for several biological compounds needed to regulate our body metabolism. Fatty acids are essential for the development of the central nervous system. Oils and fats serve as good carriers for fat-soluble vitamins A, D, E and K. In addition, some of the oils contain potent nutraceuticals like tocopherols, tocotrienols, phytosterols, phytosteryl esters, oryzanol, squalene, lignans, beta carotene, polyphenols etc.,

Visible and Invisible Oils & Fats: Visible oils and fats, such as cooking oils, ghee, butter, vanaspati, and margarines, are commonly used in kitchens. Oils and fats are also found in foods like cereals, millets, legumes, and pulses (1.5–3% fat). Foods high in fat include wet coconut (40%), dry coconut (60%), groundnuts (45%), almonds (55%), cashews (50%), walnuts (60%), pistachios (40%), papad, pickles (10–30%), paneer (15%), cheese, cream, milk, ice cream (5–15%), bakery items (about 15%), sweets, snacks, potato chips (30–50%), other snacks (15–40%), meat (10%), and egg yolk (25%). According to NIN-Indian Council of Medical Research (NIN-ICMR) estimates, about 20 g in rural population and 50 g among urban middle-income and high-income groups may consume these invisible fats unknowingly. Hence it is necessary to consider the invisible fat intake while consuming dietary intake of visible fat.

Global Recommendations for Oils & Fats Requirement: Most of the global health organizations recommend the intake for total dietary fat (visible plus invisible fats) in adults ranges between 20 to 35% of total energy intake per day. In India, the recommended dietary guideline of NIN-ICMR for the total dietary fat intake is approximately 30% of total energy. For active individuals, the fat intake may be up to 35% of total energy intake per day. For example, if an individual consumes 2000 kcal of energy per day, then 30% of 2000 kcal i.e. 600 kcal (equivalent to approximately 65 g) must come from total fat (visible + invisible). However, after considering the invisible fat consumption, visible fats may be restricted to 20-50 g (4 to 10 tablespoon full) per person/day depending on the level of energy (calorie) requirement, which is based on physical activity and physiological status. As per NIN-ICMR dietary guidelines, it is recommended that adult women or men with sedentary lifestyle limit daily fat into take to 20 and 30 g of visible fat (cooking oil) respectively. After considering these general guidelines, on average not more than 27-30 g visible fat (cooking oil) is required for a 2000 Kcal diet/day

Cold Pressed Oil vs Refined Oils: Oils and fats are available in the market with different descriptions like kachi ghani oil, expelled oil, double filtered oil, cold pressed oil, virgin oil, refined oil etc. All these forms of oils and fats are permitted by FSSAI with appropriate specifications. Hence all these oils and fats are safe, and one can consume any of these oils and fats. We must remember that all the solvent extracted oils must be refined before human consumption. Some of the common oils like groundnut, sesame, coconut, mustard, safflower oils which are extracted using expelling technique or cold pressed process can be consumed without refining if they are processed using high quality feedstock. However, in some cases, even expelled oils may contain some impurities or toxic substances like aflatoxin or higher amounts of free fatty acids in case of using low quality feed stock, which adversely affect safety, flavor, odor and appearance of oil. Hence, it is advisable to refine such oils for making them safer. After refining, oils will become safer, more palatable and stable against rancidity upon storage.

Only non-toxic chemicals are permitted for refining oils. FSSAI and other global agencies permit several processing aids for the refining of oils. Hence, refined oils are totally safe to use as cooking oil. Globally or in India, more than 85% of the oils consumed is refined oil. Most of the nutritional components like tocopherols, tocotrienols, phytosterols, oryzanol lignans etc. are retained in reasonably higher quantities during refining. Hence, do not believe unscientific viral videos which propagate refined oils as unsafe.

Significance of Essential Fatty Acids: Two known essential fatty acids (EFA) are linoleic acid (LA, omega-6) and alpha linolenic acid (ALA, omega-3), which are the basic Poly Unsaturated Fatty Acids (PUFA). The nomenclature is based on the position of the first double bond from the methyl end of the fatty acid molecule. If it comes on the 6th carbon atom it is called omega-6 PUFA and if it is on 3rd carbon atom, then it is omega-3 PUFA. EFAs are not synthesized by the body and we must provide them through diet as the role of these PUFA is very crucial in the synthesis of biologically important lipids in the body. EFAs are the components of cell membranes, structural elements of gonads and mitochondrial membrane. They are required for brain growth and development, healthy vision and for preventing fatty liver formation. EFAs are precursors of eicosanoids. EFAs perform cardio protective role by lowering serum cholesterol and increasing HDL levels. Deficiency of EFAs may cause cardiovascular diseases, diabetes, cancer, age-related functional decline, retarded growth in children, reduced fertility, pathologic changes in the skin etc. Omega 3 PUFA generates 3 series prostaglandins and 5 series leukotrienes which have anti-inflammatory activity. On the other hand, omega 6 PUFA generates 2 series of prostaglandins and 4 series of leukotrienes which are pro-inflammatory in nature. Therefore, a balance of omega 6 to omega 3 PUFA is recommended for maintaining good health.

Most of us consume plenty of omega-6 fatty acid, but not enough omega-3 fatty acid. Due to the low content of ALA and high content of LA in common edible oils, omega-6 to omega-3 ratio is quite high. A very high ratio promotes the pathogenesis of many diseases, including cardiovascular disease, cancer, and inflammatory and autoimmune diseases. Increased levels of omega-3 PUFA may lower the incidence of many chronic diseases that involve inflammatory processes. Hence, it is preferable to take at least 1 g per day of ALA either as supplement in capsule form (like flax seed oil or chia seed oil) or in the form of omega-3 fatty acid containing oil.

Nutraceuticals Present in Oils and Fats: Several minor nutritional constituents like phytosterols, tocopherols, carotenoids, oryzanol, polyphenols, lignans etc. contain in oils and fats with biological and health functions. For example, rice bran oil contains oryzanol, which has potent hypocholesterolemic activity and due to this reason, rice bran oil is known as heart oil. Rice bran oil and palm oils contain most potent tocotrienols in addition to tocopherols. Sesame oil contains sesamin, sesamolin, and sesamol, which are known as lignans with several biological and health functions including antioxidant activity. Olive oil contains poly phenols with good antioxidant property. Value of oils enhance with the presence of the nutraceuticals in addition to balanced fatty acid profile.

Fatty Acid Composition of Individual Oils: Oils and fats contain three types of fatty acids namely Saturated fatty acids (SFA) Monounsaturated fatty acids (MUFA) and Polyunsaturated fatty acids (PUFA). SFAs raise blood cholesterol and LDL cholesterol (bad cholesterol). MUFA lowers blood cholesterol and lowers LDL cholesterol. PUFAs are further classified into omega 6 and omega 3 fatty acids. The basic PUFA namely linoleic acid (omega-6) and linolenic acids (omega-3) are known as essential fatty acids since these cannot be synthesized in the body and must be provided along with the diet. PUFAs can reduce the levels of plasma cholesterol and thereby provide some protection against cardiovascular diseases. Generally, oils and fats are characterized based on the fatty acid composition. The following table provides a general idea about the common edible oils.

Fatty Acid Composition (wt%) of Common Edible Oils (Approximately Averaged Figures)

Edible oil	SFA	MUFA	PUFA		Remarks
			Omega-6	Omega-3	
Optimum Level [a]	<28*	>33-43	>28-33	>4**	
Coconut	92	6	2	0	*SFA Rich Oil*
Palmolein	40	50	10	0	*SFA/MUFA-Rich Oils*
Olive	20	70	10	0	*MUFA Rich Oils*
Groundnut	20	50	30	0	
Rice bran	20	45	33	2	
Sesame	16	42	42	0	*MUFA/PUFA-Rich Oils*
Sunflower	10	25	65	0	*PUFA (Omega-6) Rich Oils*
Safflower	10	15	75	0	
Cottonseed	25	30	45	0	
Corn	15	30	54	1	
Soybean	14	24	55	7	*PUFA (Omega 6 &3)-Rich Oils*
Mustard	6	68	16	10	*MUFA & Omega-3 Oils*
Canola	6	62	22	10	
Rapeseed	8	62	20	10	
Linseed	10	20	15	55	*PUFA (Omega 3)-Rich Oils*
Chia seed	10	10	20	60	

aBased on the recommendations of Global Health Organizations (WHO/FAO and NIN-ICMR)
*Recommended to decrease further; **Linolenic acid (omega-3) to consume minimum 1 g per day

Global (World Health Organization, WHO) and National (NIN-Indian Council of Medical Research, NIN-ICMR) Health Organizations recommend that SFA intake should not exceed 10% of total energy. The intake of PUFA should be 8-10% of energy intake. The remaining 8-10% of fat calories can be derived from MUFA. According to FAO/WHO Guidelines, replacing SFA with PUFA or MUFA decreases LDL cholesterol concentration and the total/HDL cholesterol ratio. So, it is advisable to increase the consumption of MUFA or PUFA content by decreasing SFA. In the above Table, the first row provides the optimum level of fatty acids required as per these recommendations when converted into absolute values. Interestingly, no single vegetable oil can meet all the nutritional and dietetic requirements. As seen in the above table individual oils are either SFA-rich or MUFA-rich or PUFA-rich or do not contain omega 3 fatty acid. The following are the attributes of all the major edible oils.

- Coconut oil contains medium chain saturated fatty acids that are easily metabolized. However, it contains less amounts of MUFA and PUFA. Hence, if someone consumes only coconut oil without any other source of oil for MUFA and PUFA, it may not be good for their health in the long run.

- Palmolein oil is rich in SFA and MUFA with lower content of PUFA. Some viral videos propagate that palm oil is not a healthy oil, which is not correct. Palm oil is a safe oil to consume and there is no scientific evidence for adverse health effects. Palmolein contains tocopherols and tocotrienols which are natural antioxidants. Palmolein may be consumed along with PUFA-rich oils like soybean, sunflower and safflower. Soybean oil may be blended with palmolein in 1:1 ratio for getting optimum fatty acid ratio including the required omega 6 to omega 3 ratio.
- Olive oil is rich in MUFA that helps lower LDL Cholesterol. However, olive oil contains lower amounts of PUFA. Olive oil contains polyphenols which are natural antioxidants. If someone consumes only olive oil without any other source of oil for PUFA, it may not be good for their health in the long run. Hence, olive oil may be consumed along with PUFA-rich oil like sunflower oil, soybean oil etc.
- Groundnut oil contains MUFA and omega-6 PUFA that helps lower plasma cholesterol. This oil contains reasonable amounts of SFA and does not contain omega-3 fatty acid. Hence minimum 1 g of omega 3 fatty acid must be consumed per day in addition to this. Groundnut oil contains tocopherols which are natural antioxidants. Double filtered groundnut oil may have the contamination of aflatoxins if spoiled groundnuts are taken for extraction. Refined oil is free of aflatoxins, but refined oil does not have the characteristic flavor of groundnut oil.
- Rice bran oil (RBO) contains MUFA and omega-6 PUFA that helps lower plasma cholesterol and is known as heart friendly oil. This oil contains reasonable amounts of SFA and contains 1-2% of omega-3 fatty acid. As this omega-3 fatty acid may not be sufficient, it is preferable to take minimum 1 g of omega 3 fatty acid per day in addition to this. RBO contains both tocopherols and tocotrienols. RBO also contains oryzanol which has hypocholesterolemic activity and several other health benefits. Hence, RBO is one of the healthiest oils for health and nutrition.
- Safflower oil, Cottonseed oil, Sunflower oil and Corn oils are rich in PUFA (omega-6 fatty acid, Linoleic acid) that help lower plasma cholesterol. These oils contain lower amounts of MUFA. However, these oils do not contain omega-3 fatty acid (ALA). Hence minimum 1 g of omega 3 fatty acid must be consumed per day in addition to these oils. Cottonseed and Sunflower Oils contain higher content of tocopherols which are natural antioxidants.
- Sesame oil contains equal proportions of MUFA and PUFA that helps lower plasma cholesterol. This oil contains reasonable amounts of SFA and does not contain omega-3 fatty acid. Hence a minimum of 1 g of omega 3 fatty acid must be consumed per day in addition to this oil. Sesame oil contains lignans and tocopherols which are natural antioxidants. Lignans possess hypocholesterolemic and anti-inflammatory activities. Due to the strong antioxidant property, sesame oil is being used in long storage pickles extensively. Sesame oil or combination with any other oil is also a good oil for cooking purposes.
- Mustard oil contains erucic acid (long chain MUFA) in major quantities and lower amounts of omega-6 fatty acids. This oil contains omega-3 fatty acid (Alpha linolenic acid), which is an essential fatty acid that contributes to the maintenance of normal blood cholesterol. Mustard oil also contains tocopherols which are natural antioxidants. In addition, mustard oil contains allyl isothiocyanate, which has a characteristic flavor liked by some regions of the country.
- Canola and rape seed oils contain MUFA in major quantities and omega-3 in good quantities which help lowering of plasma cholesterol. However, they contain lower amounts of omega-6 PUFA and SFA. Hence, these oils may be blended with SFA rich or omega-6 rich oils for balancing all the fatty acids.

- Soybean oil contains good amounts of omega-6 fatty acid (linoleic acid) and omega-3 fatty acid (alpha linolenic acid) which help in lowering plasma cholesterol. This oil contains lower contents of SFA and MUFA. Soybean oil also contains tocopherols which are natural antioxidants. This oil may be consumed by blending with palmolein to get optimum fatty acid profile.
- Linseed/flax seed and Chia seed oils are rich in omega-3 fatty Acid (Alpha linolenic acid) that contributes to the maintenance of normal blood cholesterol. Due to higher amounts of omega-3 fatty acid, these oils are not useful as cooking oils. Both the oils are permitted by FSSAI to add to the blended oils upto 5% as a source of omega-3 fatty acid. As mentioned above, these oils are the best oils to consume to supplement omega-3 fatty acids in daily food, in case the regularly consumed oils do not contain omega-3 fatty acids. Consumption of minimum of 2 g of either flax seed or Chia seed oils provides about 1 g of alpha linolenic acid (omega-3), which is sufficient for general health and nutrition.

How to Choose an Edible Oil with Optimum Fatty Acid Composition?: It is very clear from the above information that no single oil provides the balanced fatty acid composition. Even though some oils like rice bran and groundnut provide balanced amounts of SFA, MUFA and omega-6 PUFA, we need to supplement with some other oil for getting omega-3 PUFA. Hence, one must choose combination of oils to fulfil these specifications, while considering the invisible fats being taken by individuals in their daily diet. Today, on every pouch of oil, the fatty acid content of SFA, MUFA and PUFA is available and based on that data, we can choose our own combination of oils for getting the balanced composition of fatty acids.

The NIN-ICMR has issued recommendations for obtaining suitable oil blends to achieve optimal fatty acid compositions. For instance, groundnut, sesame, or rice bran oils can be blended with canola, soybean, or mustard oils to enhance omega-3 fatty acid content. Oils high in omega-6 fatty acids, such as sunflower or safflower, may be combined with palmolein, olive, rice bran, or groundnut oils to effectively lower the proportion of omega-6 fatty acids.

The above suggested blends are only indicative, and one can be prepared on their own, based on individual taste and preference after purchasing required pouches of oils. FSSAI also allows blending of two vegetable oils in the name of multi-sourced oils (one oil must be at least 20%) and recently, third oil namely flax seed oil or chia seed oil is also allowed up to 5% to supplement omega-3 fatty acid and to maintain omega-6 to omega-3 ratio in the blend. We can also select one of these blends from the market based on the nutritional information provided on the pouch.

Role of EPA and DHA in Health and Disease: Although the body converts omega-3 fatty acid ALA into long-chain forms like DHA and EPA, this conversion is not very efficient. Hence, direct supplements of DHA and EPA are valuable for supporting cardiovascular health, decreasing blood clot formation, reducing tumour risk, and offering anti-inflammatory benefits. These nutrients contribute to hormone synthesis, immune system support, vision, healthy cell growth, and both children's brain development and general cognitive health. EPA and DHA are particularly advantageous for individuals with high triglyceride levels and can enhance visual development in preterm infants. The primary dietary sources are fish and algal oils.

According to FAO/WHO and ISSFAL guidelines, the recommended daily intake of omega-3 PUFAs is at least 1 gram of ALA (with an upper limit of 3 to 4 grams), and 0.25 to 0.5 grams of EPA and DHA (with up to 2 grams per day advised for secondary prevention of coronary heart disease). Many companies offer omega-3 fatty acids in capsule form, which can also be purchased online. Including DHA and arachidonic acid (ARA) in infant formulas or milk substitutes is important to better replicate the fat and fatty acid composition of human milk. When breast milk intake is low, the amounts of fat, LA, ALA, ARA, and DHA in complementary foods should be increased to meet recommended nutritional levels.

How the Body Processes Oils and Fats: Triglycerides, which are present in dietary oils and fats, are digested by enzymes in the gut. The resulting molecules are absorbed, rebuilt into chylomicrons, and carried through the body as lipoproteins. Short- and medium-chain fatty acids travel straight to the liver to provide energy, whereas long-chain fatty acids move first through the lymphatic system before reaching the liver. In the body, lipids become very-low-density lipoproteins (VLDL), which transform into intermediate-density (IDL) and then low-density lipoproteins (LDL). LDL acts as the main transporter of cholesterol in the bloodstream but is often called "bad" cholesterol because it contributes to plaque buildup and heart disease. Conversely, high-density lipoprotein (HDL) is labeled "good" cholesterol since it helps clear cholesterol from tissues. To gauge heart health, it's important to check total cholesterol and compare LDL to HDL; ideally, LDL should be lower and HDL higher.

Cholesterol and Trans Fatty Acids in Oils & Fats: Vegetable oils do not contain cholesterol. Only animal fats contain cholesterol. However, saturated fatty acids have the capability to accelerate the metabolism of cholesterol. Due to this reason, global health organizations recommend comparatively reducing the consumption of saturated fatty acids. Trans fatty acids (TFAs) are formed during partial hydrogenation of vegetable oils and high-temperature refining, present in products like vanaspati and margarine. TFAs increase LDL and decrease HDL cholesterol, raising cardiac risk. Their consumption negatively affects lipid profiles, endothelial function, insulin sensitivity, and is linked to diabetes, certain cancers, preeclampsia, and developmental issues in infants. To address these risks, FSSAI limited TFAs to less than 2% in oils and food products from January 1, 2022. Consumers should check nutritional labels for trans-fat content. Manufacturers can claim "zero trans" if TFAs are under 1% in oils used.

Are Loose Oils Safe to Use?: Loose edible oils could be adulterated, and it is advised not to buy loose edible oils and consume only packed edible oils selling with FSSAI license number. Sale of loose edible oils is banned by Governments in most of the states.

Precautions During Frying Oils and Fats: Repeated heating or deep frying of oils and fats for long hours results in oxidation of polyunsaturated fatty acids leading to the generation of compounds which are harmful and toxic and may increase the risk of cardiovascular diseases and cancer. Oils containing high amounts of saturated fatty acids such as coconut oil, palmolein etc. or high amount of mono-unsaturated fatty acid containing oils such as groundnut oil, refined rice bran oil, high oleic sunflower etc. are preferable for frying. The FSSAI regulations state that used vegetable oil or fat exceeding 25% total polar content is not safe for consumption. At household level, oils once used for frying should be filtered and may be used for curry preparation. The same oil should be avoided to use for frying again. Such oils should be consumed in a day or two and storing used oils for a long time should be avoided, as the rate of deterioration is high in such oils.

Fortification of Oils and Milk with Vitamin A and D: Oils and fats are good carriers for the fat-soluble vitamins like A and D. Hence, FSSAI has permitted to fortify cooking oils and milk with both Vitamin A and D vitamins. All the manufacturers who are fortifying the oils or milk with Vitamin A and D exhibit F+ logo on their pouches. As most of the population is suffering from Vitamin A and D deficiency, it is advisable to consume fortified oils and milk.

Useful Tips for the Consumption of Oils and Fats

- **Don't believe unscientific claims:** Exaggerated claims like prevention of heart attacks, diabetes etc. are not allowed by either Codex or any Other Country-specific regulatory agency like FSSAI. Hence, one must be very cautious about the misleading and exaggerated claims for oils and fats being publicized by the manufacturers.
- **Oils are not everything for health:** Oils certainly help to maintain our health. However, the overall health depends on balanced diet including healthy oils, physical activity, controlling stress etc. Don't believe that one quality food ingredient takes care our total health. World Health Organization propagates for reduced sugar, reduced trans/saturated fat and reduced salt for good health.

- **How much cooking oil is required per day:** About 25 to 30 g oil per day per person is sufficient as we are consuming some invisible fats in the form of natural and processed foods
- **Balanced fatty acid profile:** SFA (less than 20%), MUFA (more than 40%) and PUFA (more than 30%) balance is very important while selecting the oil. About 4% omega-3 fatty acid is also necessary for getting a minimum of 1 g of omega-3 fatty acid (ALA) per day. As no oil exhibits balanced fatty acids, it is advisable to consume a combination of oils to obtain the balanced fatty acids.
- **No cholesterol:** Cholesterol is found only in animal-source foods. No plant-based oil contains cholesterol and hence do not believe that some oils contain cholesterol, and some do not contain cholesterol.
- **Importance of omega-3 fatty acid:** Most of the oils do not contain omega-3 fatty acids. Only mustard oil, soybean oil and canola oil contains reasonable amounts of omega-3 fatty acids. However, these oils are not popular every part of the country. Hence, ALA-rich oil like linseed (flax seed) or chia oil may be added upto 5% in the oils which do not contain omega-3 to obtain at least 1 to 2 g of ALA. Flax seed oil capsules may be consumed everyday as a source of ALA. Flax seed or chia seed powder may also be consumed upto 5 to 10 g every day in a suitable form like pickle powder to get about 1 to 2 g of ALA. Few walnuts may be consumed to get some omega-3 fatty acid (>60% oil with 15% ALA).
- **NIN-ICMR Dietary guidelines:** Use Oils and fats in moderation; Using a diverse variety of oilseeds, nuts and whole grains, provides a balance of all fatty acids especially to meet daily needs essential fatty acids
- **Rice bran oil:** Rice Bran Oil has a close balance of fatty acids except ALA (omega 3). Hence a minimum of 1 g of omega 3 fatty acid must be consumed per day in addition to rice bran oil. Rice bran oil is known as heart friendly oil as it contains nutraceuticals like oryzanol, tocotrienols etc. This is a good oil to blend with any other oils for getting the benefit of the nutraceuticals present in it.
- **Sesame oil:** Sesame Oil contains both MUFA and PUFA in about 40% quantities. Hence minimum 1 g of omega 3 fatty acid must be consumed per day in addition to this. Sesame oil is known for its high oxidative stability as it contains nutraceuticals like lignans, tocopherols etc. This oil is good for pickles and cooking purpose. Rice bran oil and sesame oils in a ratio of 4:1 may be a good combination for health and nutrition along with 1 to 2 g of omega 3 fatty per day.
- **Soya bean oil:** Soybean oil contains omega-3 fatty acid but does not have the balance of SFA and MUFA. Hence, soybean oil may be blended with SFA rich oils like palmolein or MUFA-rich oils like olive oil for getting optimum fatty acid ratio including omega-3.
- **Palm oil is not toxic:** Even though there is lot of negative propaganda on palm oil, there is no scientific evidence to link palm oil with lifestyle diseases. Meta-analysis of several clinical trials indicated that palm oil did not show any significant impact on pro-inflammatory markers and conventional risk factors for cardiovascular diseases. Hence, Palm oil is a safe oil and do not believe viral videos blaming this oil. In addition to the soybean oil combination, one can blend palmolein with omega-6 fatty acid rich oils like sunflower and safflower oils. However, a minimum of 1 g of omega 3 fatty acid must be consumed per day in addition to this combination.
- **Importance of long chain PUFAs:** The long chain PUFAs of n-3 (DHA and EPA) are essential during growth and development. It is advisable to consume fish oil or Algal Oil capsules every day to get about 250 mg of EPA and DHA to maintain good health.
- **Frying tips:** Do not fry oil too much. Avoid eating roadside fried foods



Evolution of Pharmaceutical Industry in Telangana & Andhra Pradesh: Current Scenario and Future Perspectives

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Introduction: The Pharmaceutical Industry in India has grown rapidly over the years and is currently valued at approximately US$55–58 billion, with an expected growth to US$120-130 billion by 2030. India is often referred to as the "Pharmacy of the World" and has emerged as the largest supplier of generic medicines (20% by volume) and vaccines (60% by volume) globally.

The states of Telangana and Andhra Pradesh have been the major contributors to the growth of the Indian Pharmaceutical Industry, with Telangana dominating in bulk drug production (nearly 50% of India's experts), vaccines, and biotech innovation. The region of Andhra Pradesh is fast emerging, strong in APIs and biotech. With great growth potential, the two states have been attracting significant investment. They are poised to grow stronger with favourable policy support from the government, a conducive ecosystem for biotech innovation, generics, R&D, manufacturing, and emerging integrated infrastructural facilities, such as bulk drug parks, Genome Valley, and Pharma City.

Genesis: The genesis of the pharmaceutical industry in the regions of Telangana and Andhra Pradesh can be traced to the establishment of Indian Drugs & Pharmaceuticals Limited (IDPL) in Hyderabad (Balanagar) in 1967. IDPL was set up in the year 1961 by the Government of India with the technical assistance from the USSR, to enable the country to attain self-sufficiency in life-saving drugs. IDPL has pioneered in the manufacturing and export of bulk drugs since the 1970s. The presence of IDPL in Hyderabad led to the development of an industrial estate at Jeedimetla in 1977, which spurred the growth of several small and medium-sized enterprises (MSMEs) to augment IDPL's large-scale production of essential bulk drugs such as vitamins, sulphas, and Chloroquine. IDPL's establishment in Hyderabad has led to the growth of a large pool of skilled scientists, engineers, and technical experts. IDPL's ecosystem has provided an ideal environment for private companies, including Dr. Reddy's Laboratories, Aurobindo Pharma, Natco, and Divi's Laboratories, to grow. IDPL played an important role in making Hyderabad a global pharmaceutical hub and a major contributor to India's bulk drug production and exports.

The presence of IDPL and the Industrial estate in Jeedimetla enabled the development of a vibrant ecosystem of research institutions and industry associations, thus propelling the growth of the industry in this region. The legacy of IDPL continued with the setting up of the National Institute of Pharmaceutical Education and Research (NIPER) as an Institute of National Importance by the Department of Pharmaceuticals, Government of India, in the year 2007 at IDPL Research Centre. Ever since its inception, NIPER-Hyderabad has been contributing to the Pharmaceutical Industry by providing highly skilled human resources and carrying out advanced research in the areas relevant to the pharmaceutical industry.

Despite the declaration of IDPL as a "sick" unit and subsequent liquidation by the Government of India in 2021, the ecosystem fostered by IDPL accounts for nearly 40% of India's bulk drug production, a major portion of global vaccine production, and NIPER as a source of well-trained manpower and a provider of R&D solutions.

Current Scenario: The region of Telangana has a long-standing reputation as India's "Bulk Drug Capital" and "Vaccine Hub", housing over 800 life sciences companies and more than 250 US FDA-approved sites. Major generic & biotech companies such as Dr. Reddy's Laboratories Ltd., Aurobindo, Divi's Laboratories, Natco Pharma, MSN Laboratories, Bharat Biotech, Biological E, etc., are in this region. Over the last four years, Telangana has attracted more than Rs. 10,000 crore investment in the life sciences sector, contributing to a major share of India's pharma output and exports. During 2019-20 (up to December 2019), pharmaceutical exports from the state stood at US$3.48 billion. India's first life sciences cluster, Genome Valley, hosts over 200 companies, R&D, and manufacturing. The newly proposed Pharma City by the government of Telangana is designed to be the world's largest integrated pharma hub.

The region of Andhra Pradesh is being reckoned as the Rising Force in the Indian Pharmaceutical sector, by leveraging the government's support and huge investments for clusters. Several industries focused on Active Pharmaceutical Ingredients, Specialty chemicals, and Medical Devices are in the Jawaharlal Nehru Pharma City (JNPC) in Visakhapatnam. The region has become attractive for the growth of the industry with the upcoming Bulk Drug Parks, the expanding biotech sector, and its proximity to coastal areas for enabling exports.

Both Telangana, with its established ecosystem, and Andhra Pradesh, with rapid scaling up, have become critical global suppliers of pharmaceuticals. These two states share several complementary strengths & ecosystems. The robust infrastructure, major investments, and supportive government policies are the major driving forces for pharmaceutical industrial growth.

Global Footprint: Over the years, the regions of Telangana and Andhra Pradesh have emerged as prime destinations for several global pharmaceutical, biotech, and medical device companies to establish their Global Capability Centres (GCCs), manufacturing, and R&D units. The Global Capability Centres (GCCs) of several MNCs, viz., Sandoz, Bristol Myers Squibb (BMS), Novartis, Eli Lilly, Amgen, Bayer, Johnson & Johnson, Merck Life Sciences, are already established in Hyderabad, and many more are expected to join. It is also interesting to note that global players such as Eurofins Scientific, Bristol Myers Squibb (BMS), Meishi Pharma (a subsidiary of Taiwan-based Lotus), Medtronic, and ALS (Australia-based) are setting up their R&D/manufacturing units in Hyderabad. Takeda (Japanese major) partnered with Biological E to manufacture dengue vaccine doses annually from Genome Valley. The Japanese Pharmaceutical giant Eisai Pharmaceuticals India has established its state-of-the-art R&D center in Vizag in Andhra Pradesh. The increasing footprint of the global payers in Telangana and Andhra Pradesh highlights the region's pivotal role in the global pharmaceutical supply chain, contributing significantly to India's pharmaceutical production and exports.

Value-Driven Research & Innovation Potential: With successes built on generics and bulk drugs, many Indian Pharmaceutical industries have been shifting towards value-driven research with innovation potential. The presence of several multinational companies, Viz, Novartis, GSK, DuPont, etc., and reputed academic and research Institutes, and a vibrant startup ecosystem, has fostered a collaborative environment, which accelerated the pace from groundbreaking ideas to market-ready products, enabling a full spectrum of activity from discovery to global delivery.

In addition, the availability of specialized R&D Infrastructure, which includes state-of-the-art laboratory facilities, scale-up facilities, manufacturing sites, and large animal facilities for preclinical testing and bio-process scale-up facilities (like the B-Hub accelerator), in well-developed Industrial Parks, such as Genome Valley, Industrial/Knowledge Parks, Special Economic Zones (SEZs), and multi-tenanted wet and dry laboratories, is further accelerating the conduct of high-quality, value-driven research and development.

Further, the establishment of several Incubation & Innovation Centers is creating an environment conducive for several aspiring entrepreneurs to translate their research into commercial success. The state

of Telangana alone is home to more than 20 well-established incubators, focused on the healthcare and Pharma sectors. The resulting impact is creating more employment opportunities, hastening scientific breakthroughs, and thus contributing significantly to the local and national economies

In turn, the state of Andhra Pradesh is moving at a rapid pace and has emerged as a growing Biotech Partner. Companies in this state are moving towards biotech, medical devices, and digital health, thereby leveraging the existing pharma manufacturing strength.

Contract Research, Development, and Manufacturing Organization (CRDMO): The CRO and CDMO industries in Telangana and Andhra Pradesh have become key strategic partners in the pharmaceutical value chain globally, moving from their earlier positioning as relatively low-cost service providers. These regions have emerged as the epicenter of India's strategic landscape and are likely to achieve a CAGR of 13-15% in the CRDMO segment by 2025, compared with the global growth rate of around 7-9%.

A diversified global supply chain and a strategic focus on high-value, innovation-driven services are the key factors for the robust expansion of the CRDMO sector in these two states. Consequently, the region is gaining momentum to position itself as an integral part of the global pharmaceutical value chain. Major industry players like Aurobindo Pharma, Sai Life Sciences, Dr. Reddy's Laboratories, Aragen Life Sciences, Aurigene Pharmaceutical Services Ltd., Syngene International Ltd., and Eurofins Advinus Hyderabad have committed significant new investments in this region.

Several geopolitical factors, such as the U.S. BIOSECURE Act, have been forcing global pharmaceutical companies to lower dependency on single-source suppliers in China and to diversify supply chains toward India, a strategic alternative that is referred to as the "China+1" strategy. The CRDMO sector in this region is rapidly transitioning from low-cost generics to high-value complex domains, namely ADCs, biologics, and gene therapies, which demand high-order scientific and technological capabilities. Availability of skilled scientific talent and the presence of several USFDA-approved manufacturing facilities are benefiting the industry in adhering to the international quality standards. The CRDMO players in this region have equipped themselves adequately to offer integrated CRDMO (Chemistry, Manufacturing, and Biologics Development and Manufacturing Operations) services, from drug discovery through commercial production to support the entire drug development pipeline and act as integrated, end-to-end partners for global biopharmaceutical organizations.

With these developments, the sector has evolved to become an integral partner in the global pharma R&D and supply-chain network, contributing significantly to the improvement of efficiency and speed in drug development on a global scale.

Key Growth Drivers: Several factors, such as cost efficiency, global realignment, regulatory compliance, and supply chain resilience, have contributed to the transformation of the CRDMO sector in this region to become an innovative solution provider from a mere manufacturing hub.

a) **Cost Efficiency:** Both states offer 50-70% lower R&D and manufacturing costs compared to the US and Europe, with an English-speaking pool of talented scientists and engineers.

b) **Global Realignment:** The Indian states like Telangana and Andhra Pradesh have gained remarkably from the "China+1'' strategy, whereby global pharmaceutical firms are looking towards diversification of their supply chains beyond China.

c) **Regulatory Compliance:** With many USFDA, WHO, and other approved facilities, both states enhance compliance capability and build global confidence in the quality of the CRDMO sector in this region.

d) **Strategic Partners in Innovation:** The region has moved from simple, generic manufacturing to managing complex, high-value services such as ADCs, cell and gene therapy, and complex APIs. This strategic shift has positioned them as integrated, strategic partners rather than just low-cost vendors.

e) **Supply Chain Resilience:** The enhanced capabilities of the CRDMO sector have added to a more resilient and diversified global pharmaceutical supply chain.

f) **R&D Hub:** Hyderabad is turning out to be the R&D and GCC hub for global pharma giants like Sanofi, Bristol Myers Squibb, and Johnson & Johnson, driving innovation, AI-powered clinical trials, and global supply chain orchestration from the city.

In addition, the synergistic Industry-Academia Collaborations are also accelerating the growth.

To name a few, the collaborations between the National Institute of Pharmaceutical Education and Research (NIPER) in Hyderabad and the Indian Drug Manufacturers' Association (IDMA) and Bulk Drug Manufacturers Association of India (BDMAI) aim to fill the gap between academic research and industrial application.

The partnership between the Telangana Council of Higher Education and the Bulk Drug Manufacturers Association of India will ensure that educational training is kept in tune with the requirements of the industry and thereby provide the much-needed skilled manpower to its R&D and manufacturing facilities.

Similarly, the state of Andhra Pradesh is promoting a favourable atmosphere in carrying out life sciences R&D with a particular emphasis on medical devices and state-of-the-art research facilities. The Public-Private Partnerships (PPPs) such as Andhra Pradesh MedTech Zone (AMTZ) in Visakhapatnam, a government-supported park, provide shared infrastructure for research, testing, and manufacturing of medical devices, which has benefited the life sciences sector. The Havih EnviroScience's formed a significant partnership with the Government of Andhra Pradesh and the Andhra Pradesh Centre for Advanced Research on Livestock Limited (APCARL) to access advanced R&D and BSL-4 facilities. This collaboration emphasizes developing and manufacturing next-generation anti-infective medications, thus showcasing a direct PPP in drug development.

Challenges and Opportunities: While the growth of the industry has been steady and significant, the following challenges are of concern, which need serious attention.

a) Low investment in Innovator drugs: Except for a few companies, viz., Dr. Reddy's Laboratories Ltd. (in the past), the investment in Innovator products & New Drug Discovery has been low compared to generics and biosimilars, potentially limiting long-term growth opportunities.

b) Import dependency of critical APIs & KSMs: While Telangana has traditionally been a leader in APIs, and Hyderabad is known as the Bulk Drug Capital, reliance on import of key starting materials (KSMs) and Active Pharmaceutical Ingredients (APIs), particularly from China, is of concern. This could potentially create supply chain disruptions and price volatility.

c) The complex and dynamic regulatory compliance of domestic and international regulatory standards (e.g., US FDA, EMA) often poses challenges to the Indian Companies.

Despite the challenges being faced, the Indian Pharmaceutical companies are resilient and are seizing the following opportunities.

a) Increased global demand: The rapid rise of global healthcare needs, particularly in emerging markets, presents significant export opportunities.

b) Opportunities for specialized medicines: Advances in biotechnology offer new opportunities for the development of specialized products for personalized medicine, rare genetic disorders, and innovations to address resistance to the existing drugs, particularly in the areas of antibacterials and anticancer agents.

c) **Integration of digital tools:** The increased integration of digital tools and automation in the R&D and manufacturing processes enables the enhancement of R&D efficiency, streamlines supply chains, and improves overall operational effectiveness.

d) **Rise of CRAMS/CDMO players:** The Telangana and Andhra Pradesh regions have become the home for many key contract development and manufacturing units, which enable significant growth through global alliances.

In conclusion, from the establishment of IDPL to the emergence as a global player in the pharmaceutical sector, the evolution of the pharmaceutical industry in the states of Telangana and Andhra Pradesh has been remarkable. With the continued resilience of the Indian players and the proactive measures by the Governments in these states, the industry is poised to scale further heights.



Regenerative Medicine: Paradigm Shift in Health Care

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As Biomedical research continues to advance, it is imperative to balance between scientific progress with ethical considerations ensuring that the journey of regenerative medicine continues to be marked by innovation, responsibility, and transformative healing. In this new era of healthcare, regenerative medicine and stem cell treatment form important arms with their revolutionary promise to cure many injuries and diseases which were thought to have had no hope of recovery. The field of regenerative medicine explores potential to revolutionize healthcare by creating new ways to restore the damaged or sick organs, tissues, or cells to restore the functions. The identification and use of stem cells have been pivotal to the domain of regenerative medicine, owing to its intrinsic flexibility, self-renewal and their potential for multilineage differentiation to generate diverse range of cell types. Indeed, the success of regenerative medicine trace back to middle of twentieth century when the first bone marrow transplant was successful in 1956.This innovative approach facilitated several researchers to comprehend the therapeutic capacity of stem cells towards clinical implementation.

Two major findings including Embryonic stem cells (ESCs) and induced pluripotent stem cells (iPSCs) brought about a significant transformation in the field of stem cell research. ESCs offers promise due to their pluripotent characteristics opening up new opportunities subsequent to their first isolation in 1998, making them a powerful tool to study developmental regulation/Nutrigenomics and other therapeutics. However, their applications continue to be a topic of ethical debate, prompting a need for stringent regulatory frameworks requiring a meticulous and comprehensive strategy for clinical settings. In 2006 iPSCs was a step way forward to generate patient-specific cells created by reprogramming adult cells using ESCs specific transcriptional factors. Although of less ethical concerns compared to ESCs their merit of long-term clinical applications warrant their ethical means for patients. Nevertheless, these breakthroughs have expanded the possibilities to widen the field of biomedical research leading to several regenerative approaches to address cardiac health (cardiomyocytes) , diabetes (Insulin producing cells), Parkinson's disease (dopamine neurons), acute liver failure (hepatocytes) presenting a revolutionary approach and proven with efficacy studies demonstrated at the preclinical phase.

The somatic Stem Cells, constituting the adult Mesenchymal Stem cells (MSCs) in are limited to differentiating cell types compared against iPSCs and ESCs, and are harvested from organ or tissue as per the requirement. MSCs form key player in regenerative medicine, are highly valued due to their multipotent differentiation abilities, exhibit remarkable self-renewal capacity, long-term proliferation ex vivo, paracrine potentials (secrete bioactive molecules), immunoregulatory and anti-inflammatory finding their way for suitable clinical applications in auto immune disorders, inflammatory diseases, Communicable and Non-communicable diseases and for organ transplantation. With advancement in tissue engineering integration of stem cells into suitable biological scaffolds has revolutionized the treatment of spinal cord injuries and wound healing and severe burns expanding their frontiers in allied

fields. The inherent pack of cytokines, growth factors including angiogenic specific present in MSCs pave way their application to enhance dissipation of oxygen and nutrients to the tissues to regenerate and accelerate repair process.

Clinical Trials and Applications

As per Clinical Trials. Gov (across globe), there are currently over 5,000 registered clinical trials involving stem cell therapies, emphasizing the widespread interest in this field. These trials span a range of organs, including the lung, kidney, heart, pancreas and liver. A significant focus of these trials is on assessing the safety and effectiveness of stem cell therapies, a critical step towards their widespread clinical adoption. Some of the successful trails include Treatment of Keratoconus with MSCs, Stem Cells in Immune Modulation and Neoangiogenic Regeneration, Autologous Bone marrow derived stem cells in treating heart disease, Autologous Bone marrow derived stem cells in treating Spinal Cord Injuries and osteoarthritis, allogenic bone marrow stem for osteoarthritis, MSCs derived Insulin producing cells for diabetes etc.

Ethical, Legal, and Social Implications

There is a wide range of complex ethical issues surrounding stem cell treatment and regenerative medicine. Among the most divisive moral issues is the potential use of embryonic stem cells (as discussed) necessitates killing an embryo. The potential for genetic modification using stem cell therapies also raises concerns especially about their long-term effects and unintended consequences of altering the human genome , Further, regulatory guidelines for regenerative medicine and stem cell therapy varies significantly across different countries, reflecting diverse ethical perspectives and healthcare policies including India In India, lack of clear-cut regulations can lead to ambiguities in the implementation and oversight of stem cell therapies, impacting both research and clinical applications. U.S. stem cell therapy regulation is more governed by the Food and Drug Administration (FDA) and because of this categorization, every stem cell product seeking clinical approval must undergo extensive research to guarantee safety and effectiveness. Thus, regenerative medicine and stem cell therapy are currently navigating a landscape of significant challenges with limitations that needs to be addressed to fully realize their healthcare potential and capabilities. The manufacturing and processing of stem cells as pharma products for therapeutic use present logistical challenges such as scaling up production, maintain cell quality and viability is a complex process that requires advanced technological upgradations like GMP validity etc. Improvised technology development, purity, and overall quality of manufactured products with optimal preclinical model systems are required to predict clinical outcomes more accurately.

Key Technologies and Core Paradigm Shifts in Recent years in Regenerative Medicine

Since a decade, regenerative research has undergone several transformative paradigms shifts landscaping from cell therapy to functional and biological restoration. The rapid growth and several breakthroughs in recent years largely attributes to the advancement in scientific knowledge, technology and methodological progress in several key areas including:

- **From Live Cells to Cell-Free systems like Secretome:** A major awareness is the transition toward secretome and exosome-based therapies, in place of biocell therapy which carry risks of immune rejection and long term tumour formation. Researchers are now focusing on the "regenerative cocktail" (growth factors, cytokines, and extracellular vesicles) that stem cells naturally release to signal tissue repair.
- **From Single-Dose to Multi-Dose Protocols:** The field is shifting from the old single-dose paradigm to multiple-dose strategies. Studies show that multiple administration of cryopreserved cells displaying high viability, to achieve effective therapeutic effects, particularly in heart ,diabetes, osteoarthritis and

inflammatory diseases.

- **Cell-Based Therapies:** The ability to create iPSCs from a patient's own cells makes them very adaptable and opens the avenues for individualized medical therapies and decreases the likelihood of immunological rejection, and has led to groundbreaking therapies in various fields, from neurology to cardiology.
- **Gene Editing Integration:** the advancement in system biology has enabled to dive deep into the cell, and stem cell technology using CRISP -Cas9 base editing allows for "off-the-shelf" universal allogeneic cells, by knocking out immune recognition genes. The researchers can now create "hypo-immunogenic" cells that avoid rejection without the need for chronic immunosuppression, and to be a boon for single cell mutations.
- **AI-Driven Precision:** As of December 2025, artificial intelligence has become foundational, projected to cut development time for new therapies by up to 40%. AI is used for Intelligent Identification, deep learning for analysing cell morphology and viability, predicting ideal conditions to guide stem cells into specific types, such as dopaminergic neurons for Parkinson's disease.

Key 2025 Breakthroughs and Market Trends

- **Expanded Indications:** Clinical trials show promise and have moved beyond oncology into chronic conditions like Type 1 Diabetes, ALS, and Systemic Lupus Erythematosus (SLE).
- **Reproductive Innovation**: In February 2025, the first iPSC-based therapy for a reproductive application (Fertile) entered Phase III trials in the U.S. to assist in fertility treatments.
- **Regenerative Market Growth:** The global regenerative medicine market is valued at approximately $18.13 billion to $24.88 billion in 2025, with projections reaching nearly $150 billion by 2033.
- **3D Bioprinting:** Integration with stem cell technology is advancing the creation of complex, functional tissues such as cardiac patches and liver organoids for transplantation.

Conclusion

In summary, regenerative medicine stands at the forefront of healthcare in medical treatment and innovations. Its integration of various technologies and methodologies paves the way for novel therapies that could fundamentally change our approach to healing and disease management in near future. This dynamic field promise(s) not only to repair but also to rejuvenate and replace damaged tissues and organs using the printing techniques, potentially altering the landscape of healthcare in profound ways. The versatility and adaptability of stem cell therapy make it a cornerstone of future medical interventions. Nevertheless, despite these exciting achievements, the ethical concerns and obstacles in the regenerative medicine sector needs to be vigilant. The therapeutic applications of stem cells extend beyond these examples, encompassing a wide spectrum of conditions, including but not limited to liver diseases, osteoarthritis, and various forms of cancer. New methods for treating complex medical conditions, including heart problems and neurological diseases, have arisen as a result of advances in tissue engineering, gene therapy



Exploring the Effects of Microgravity on Biological Systems During Space Expedition

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Introduction

Human curiosity and scientific ambition have continuously driven space exploration, transforming it from short-duration orbital missions to long-term habitation aboard space stations and ambitious plans for lunar bases and human exploration of Mars. As humanity ventures deeper into space, understanding how the space environment affects living systems has become critically important. Among the many challenges associated with spaceflight, microgravity stands out as a dominant factor influencing the structure, function, and regulation of biological systems. Microgravity refers to conditions in which the apparent effects of gravity are greatly reduced, as experienced by objects and organisms in continuous free fall around Earth. In such an environment, the mechanical forces that normally shape biological form and function on Earth are altered. Cells, tissues, and organs that evolved under Earth's gravitational pull undergo significant physiological, biochemical, and molecular changes in space. These changes have implications not only for astronaut health but also for the long-term sustainability of human life beyond Earth.

Space biology and Space medicine are the disciplines which address these challenges from complementary perspectives. Space biology focuses on understanding how living organisms respond and adapt to space conditions, while space medicine applies this knowledge to protect astronaut health, prevent disease, and manage medical emergencies in space. This conference souvenir article presents an integrated overview of space biology and space medicine, with special emphasis on the effects of microgravity on biological systems and the biomedical strategies developed to mitigate its adverse consequences.

Scope of Space Biology

Space biology is an interdisciplinary field that investigates the behavior, adaptation, and survival of living organisms in the unique environment of space. It encompasses research on humans, animals, plants, and microorganisms exposed to microgravity, space radiation, confinement, altered atmospheric composition, and disrupted light, dark cycles. The insights gained from space biology research are essential for the design of life-support systems, space habitats, and future interplanetary missions.

Human Physiology in Space

Long-term exposure to microgravity induces profound changes in human physiology. The musculoskeletal system experiences significant degradation due to reduced mechanical loading, leading to bone mineral density loss and muscle atrophy. The cardiovascular system adapts to altered fluid distribution, resulting in reduced blood volume and orthostatic intolerance upon return to Earth. In addition, astronauts experience immune suppression, neurovestibular disturbances affecting balance and coordination, visual impairments, and metabolic alterations. Understanding these physiological changes is essential for ensuring astronaut health and mission success.

Plant Biology and Space Agriculture

Plants play a vital role in future space habitats by providing food, oxygen, and psychological comfort to astronauts. However, microgravity affects plant growth orientation, nutrient transport, water uptake, metabolism, and gene expression. Research in space plant biology supports the development of sustainable life-support systems, space-based agriculture, and bioregenerative ecosystems that will be crucial for long-duration missions and extraterrestrial settlements.

Microbial Responses to Microgravity

Microorganisms such as bacteria and fungi exhibit altered growth rates, biofilm formation, virulence, and antibiotic resistance under microgravity conditions. These changes have important implications for astronaut health, spacecraft hygiene, and biotechnological applications. Understanding microbial behavior in space is essential for preventing infections, maintaining closed life-support systems, and harnessing beneficial microbes for waste recycling and resource production.

Animal and Cellular Studies

Animal models, including rodents and fruit flies, along with cultured cells, are widely used to study the effects of spaceflight on reproduction, immunity, bone and muscle health, and gene regulation. At the cellular and molecular levels, microgravity influences cytoskeletal organization, signal transduction pathways, protein synthesis, and gene expression. These studies provide fundamental insights into the mechanisms underlying biological adaptation to space.

Biological Effects of Microgravity

Musculoskeletal and Cardiovascular Changes

In the absence of gravity-induced mechanical loading, astronauts experience rapid bone mineral density loss, particularly in weight-bearing bones such as the spine, hips, and legs. Muscle atrophy affects both strength and endurance, posing risks to mission performance and post-mission recovery. The cardiovascular system adapts to microgravity through fluid shifts toward the upper body, reduced cardiac workload, and diminished vascular tone, which can lead to dizziness and fainting upon re-entry to Earth's gravity.

Immune System Alterations

Microgravity affects immune cell signaling, cytokine production, and lymphocyte activation. Studies have reported suppressed immune responses, altered inflammatory pathways, and reactivation of latent viruses during space missions. These changes increase susceptibility to infections and complicate wound healing, highlighting the importance of immune monitoring and countermeasures in space medicine.

Gene Expression and Cellular Function

Spaceflight induces significant changes in gene expression related to stress response, metabolism, DNA repair, and cytoskeletal organization. Altered mechanical forces influence cellular architecture and signaling networks, leading to changes in cell proliferation, differentiation, and apoptosis. These molecular-level alterations underpin many of the physiological effects observed in astronauts.

Psychological and Behavioral Impacts

Isolation, confinement, disrupted circadian rhythms, and high workload demands contribute to psychological stress during space missions. Astronauts may experience anxiety, sleep disturbances, mood changes, and cognitive challenges. Behavioral health support and crew cohesion strategies are therefore essential components of long-duration missions.

Importance of Space Medicine

Space medicine is a specialized branch of medicine dedicated to the prevention, diagnosis, and management of health problems associated with spaceflight. It addresses the physiological, psychological, and operational challenges faced by astronauts during short- and long-duration missions. Core areas of space medicine include musculoskeletal health, cardiovascular function, neurovestibular adaptation, immune regulation, radiation protection, mental health, and emergency medical care in remote environments.

Ensuring Astronaut Health and Mission Success

Space medicine plays a pivotal role in ensuring astronaut health and overall mission success. By developing preventive strategies, continuous health monitoring systems, and evidence-based medical interventions, space medicine safeguards the physical and psychological well-being of astronauts. Maintaining astronaut health is directly linked to operational efficiency, safety, and the successful completion of mission objectives.

Supporting Long-Duration Missions

Future missions to space stations, the Moon, and Mars involve prolonged exposure to microgravity and cosmic radiation, with limited access to Earth-based medical support. Space medicine supports these missions through autonomous medical care systems, telemedicine, personalized exercise and nutritional protocols, and structured psychological support. These measures are essential for sustaining human life and performance during extended space exploration.

Contributions to Earth-Based Medicine

Research in space medicine has led to significant advancements in Earth-based healthcare. Studies on microgravity-induced bone loss have improved understanding and treatment of osteoporosis, particularly in elderly and immobilized patients. Research on muscle atrophy has informed effective muscle rehabilitation strategies used in clinical and sports medicine. Furthermore, telemedicine technologies developed for space missions have revolutionized remote healthcare delivery, benefiting rural, disasterprone, and underserved regions on Earth.

Biomedical Countermeasures for Space Missions

To mitigate the adverse effects of microgravity, a range of biomedical countermeasures have been developed and implemented:

Exercise Protocols: Resistance and aerobic training to reduce bone loss and muscle atrophy.

Nutritional Support: Calcium, vitamin D, protein, and micronutrient supplementation to maintain skeletal and immune health.

Radiation Protection: Shielding technologies and spacecraft material innovations to minimize radiation exposure.

Psychological Support: Continuous communication with Earth, counseling, and behavioral monitoring to manage stress and mental well-being.

Life-Support Systems: Bioregenerative systems using plants and algae to recycle air, water, and waste.

Telemedicine: Remote diagnostics, health monitoring, and medical decision support for autonomous care.

Role of Lab-on-Chip Technology in Space Biology and Space Medicine

One of the most promising innovations for space biomedical research is Lab-on-Chip (LoC) technology. These miniaturized platforms integrate multiple laboratory functions onto a single chip, enabling

biological and chemical analyses with minimal resources. It has the Advantages as Compact and lightweight design, Reduced reagent consumption, Rapid and accurate diagnostics, Parallel analysis of multiple samples, Suitability for harsh space environments.

Applications in Space Missions

Lab-on-chip devices support crew health monitoring, pathogen detection, genetic and immunological analysis, environmental monitoring, and biochemical assays. Their integration with microfluidics, biosensors, artificial intelligence, and telemedicine makes them indispensable for long-duration missions where conventional laboratory facilities are unavailable.

Broader Implications for Earth-Based Science and Society

Research conducted under microgravity conditions has far-reaching benefits beyond space exploration. Insights from space biology and space medicine contribute to advances in osteoporosis treatment, muscle rehabilitation, immunology, aging research, pharmaceutical development, agricultural biotechnology, and environmental science. The translation of space-derived knowledge to terrestrial applications highlights the societal value of sustained investment in space research.

Future Directions in Space Biology and Space Medicine

As human spaceflight expands beyond low Earth orbit, interdisciplinary collaboration among biologists, physicians, engineers, and data scientists will be essential. Future research will focus on personalized medicine for astronauts, artificial gravity solutions, advanced life-support systems, autonomous healthcare technologies, and long-term health monitoring. Space biology and space medicine together will form the foundation for sustainable human presence beyond Earth.

Conclusions

Space biology and space medicine play complementary and indispensable roles in enabling safe and sustainable human space exploration. By elucidating the effects of microgravity on biological systems and developing innovative biomedical countermeasures, these fields ensure astronaut health and mission success. As humanity prepares for longer missions to the Moon, Mars, and beyond, continued interdisciplinary research in space biology and space medicine will be essential, not only for advancing space exploration but also for delivering lasting benefits to science, medicine, and society on Earth.



Bridging the Aerospace and Space

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Introduction

India's space sector has entered a phase of rapid diversification, characterised by expanding private participation, growing civil and defence demand, and increasing convergence between space, aviation, and digital infrastructure. While orbital space capabilities, satellites and launch vehicles, continue to remain strategic national priorities, there is a compelling case to systematically develop and institutionalise Near Space platforms, particularly Lighter-Than-Air (LTA) systems, as an integral layer of India's aerospace and space ecosystem.

Near Space, broadly spanning altitudes in the stratosphere, offers persistent, cost-effective, and rapidly deployable capabilities for surveillance, communication, environmental monitoring, disaster response, and logistics. High-altitude balloons, tethered aerostats, and cargo airships operating in this regime can complement satellites and unmanned aerial systems, while addressing key limitations related to cost, latency, endurance, and recoverability.

India has a long and credible legacy in high-altitude ballooning through sustained scientific programmes led by institutions such as the Tata Institute of Fundamental Research (TIFR), which have enabled world-class atmospheric, astrophysical, and cosmic-ray research over several decades. The present opportunity lies in extending this proven laboratory-scale scientific capability into societally impactful Near Space platforms, translating foundational research into applications for disaster management, communications, climate monitoring, and national infrastructure, thereby advancing a true "lab-to-society" continuum.

The vital role of Near Space as a distinct strategic domain needs to be recognised and supported through targeted policy, regulatory, industrial, and R&D interventions.. This needs to be supported by targeted policy, regulatory, industrial, and R&D interventions. There is a current strategic need for Near Space platform development, testing, manufacturing, and operations for India.

India's Space Ecosystem: From Centralised Programmes to Distributed Capability

India's space journey has historically been anchored around the Indian Space Research Organisation, whose integrated, state-led model enabled self-reliance in launch vehicles, satellites, navigation, and deep-space missions. This approach delivered substantial socioeconomic dividends, particularly in telecommunications, weather forecasting, disaster management, and navigation.

Over the past decade, India's space ecosystem has undergone a structural transformation driven by Policy liberalisation and institutional reforms, Emergence of private and startup-led innovation, Growing defence, civil, and commercial demand and Convergence with digital, AI, and data-driven services

The establishment of IN-SPACe has formalised private participation, enabling non-governmental entities to access infrastructure, launch services, and downstream opportunities. Parallel initiatives such as iDEX, TDF, and Make-in-India have further accelerated dual-use technology development.

As a result, India's space ecosystem is no longer geographically or institutionally monolithic. Multiple states are emerging as contributors to aerospace manufacturing, space applications, and R&D. In this evolving landscape, Near Space platforms represent a new horizontal capability layer that can be developed faster, at lower cost, and with broader regional participation.

Near Space: Defining a Strategic Atmospheric Layer

Near Space occupies the altitude regime between controlled civil aviation and orbital space. Despite its strategic relevance, this domain has historically received limited institutional attention, primarily due to regulatory ambiguity and technological constraints. Globally, however, leading spacefaring nations are now moving toward dedicated legal and regulatory regimes for Near Space and High-Altitude Pseudo-Satellite platforms, underscoring the need for timely institutional action.



Figure 1: The Near Space (Strategic) Layer

From a policy perspective, Near Space offers several national advantages:

- **Persistence:** Platforms can remain operational over a region for days to months
- **Affordability:** Lifecycle costs are significantly lower than satellite systems
- **Rapid deployment:** Shorter development and launch timelines
- **Recoverability and reusability:** Enabling iterative upgrades and cost efficiency
- **High-resolution, low-latency data:** Particularly valuable for ISR and disaster response

Lighter-Than-Air Technologies: A Renewed Strategic Opportunity

Lighter-Than-Air systems leverage buoyant lift, enabling long-duration flight with minimal energy expenditure. Advances in materials, avionics, autonomy, and safety systems have significantly enhanced their reliability and operational relevance.

High-Altitude Balloons

Modern super-pressure and zero-pressure balloons enable sustained stratospheric missions for Atmospheric and climate science, Earth observation and remote sensing, Communication relay and connectivity and Defence experimentation and payload validation

Aerostats

Tethered aerostats provide elevated, stationary platforms capable of hosting radar, EO/IR, SIGINT, and communication payloads, supporting Border and coastal surveillance, Maritime domain awareness, Early warning and intrusion detection and Disaster-time communication restoration

Airships

Heavy-lift cargo airships represent a transformative logistics solution for Remote and infrastructure-poor regions, Disaster relief and humanitarian assistance, Strategic and defence logistics and Low-carbon freight transport

Global Scenario: Near Space and LTA Platforms as Strategic Infrastructure

Globally, Near Space platforms and Lighter-Than-Air (LTA) systems are increasingly viewed as strategic infrastructure assets, rather than niche aerospace technologies. Major economies are investing in these platforms to complement satellites, reduce costs, and enhance national resilience across defence, communications, climate monitoring, and logistics.

International Government and Defence Programmes

Several advanced nations have operationalised or institutionalised Near Space platforms:

United States: The US has long-standing operational experience with tethered aerostats and high-altitude balloons for border surveillance, missile warning, and communication relay. Agencies under the Department of Defense actively deploy aerostat systems for persistent ISR and early warning.

Israel: Israel has extensively deployed aerostat-based radar and surveillance platforms to overcome terrain masking and ensure continuous border monitoring, particularly in contested environments.

France and Europe: European initiatives increasingly treat high-altitude balloons and airships as climate-monitoring and communication platforms, aligned with sustainability and digital sovereignty goals.

China: China has demonstrated large stratospheric balloons and airships for surveillance, communications, and scientific payloads, signalling Near Space as a strategic layer in its aerospace doctrine.

These developments indicate a clear global consensus: Near Space is emerging as the "third vertical" of national aerospace capability, alongside aviation and orbital space.

Global Scenario: Policy Perspective

Globally, countries such as the United States, United Kingdom, Japan, France, China, and Israel have introduced dedicated regulatory, policy, or institutional frameworks to govern Near Space and High-Altitude Platform Systems, recognising them as a distinct operational layer bridging aviation and outer space. Several advanced economies are investing in this layer to augment space-based and terrestrial infrastructure.

- The US has the most mature Near Space governance ecosystem, where they are regulated through a combination of FAA, FCC, and DoD authorities.
- The UK Civil Aviation Authority (CAA) has issued specific guidance and regulatory pathways and has linked Near Space platforms to National connectivity objectives, Climate monitoring and Defence surveillance.

- France and select EU member states have introduced national authorisation frameworks. These are aligned with EU aviation safety rules, while recognising Near Space as a special category outside conventional aviation.
- Japan treats Near Space primarily as critical digital infrastructure, not merely aerospace experimentation. Japan's Ministry of Internal Affairs and Communications (MIC) has issued policies for HAPS-based communication networks and Integration with 5G/6G and NTN systems.
- China has explicitly incorporated Near Space platforms into National aerospace and defence planning, Surveillance and communication programmes.

For India, facing complex border, maritime, climate, and infrastructure challenges, Near Space platforms offer a scalable solution that bridges gaps between satellites, UAVs, and ground systems.

Complementing, Not Replacing, Satellites

Near Space platforms are not substitutes for satellites, but complementary assets within a layered national architecture.

Dimension	Satellites	Near Space LTA Platforms
Capital cost	*Very high*	*Low to moderate*
Deployment time	*Long*	*Short*
Persistence	*Orbit-dependent*	*Station-keeping possible*
Recoverability & Reusability	*No*	*Yes*
Upgrade cycle	*Slow*	*Rapid*

An integrated architecture, combining satellites, Near Space platforms, UAVs, and ground systems, enhances national resilience, redundancy, and responsiveness.

Indigenous Capability and Economic Spill-Overs

Near Space platforms offer an opportunity to build end-to-end indigenous capability in:

- Advanced polymer and laminate materials
- Lightweight structures and tendon systems
- Hydrogen safety and storage technologies
- Autonomous flight control and AI-driven data analytics

Unlike traditional satellite programmes, Near Space systems enable deeper participation from MSMEs, startups, academic institutions, and state-level industries, generating employment and regional development.

Regulatory and Institutional Considerations

Near Space lies at the intersection of civil aviation, space, telecommunications, and defence regulation. Key stakeholders include IN-SPACe, DGCA, Ministry of Defence / DRDO, WPC and MoEFCC and State Authorities

A coordinated national framework, potentially under a mission-mode programme, would significantly reduce uncertainty and accelerate early adoption.

Global Scenario and Strategic Imperative

Globally, Near Space platforms are transitioning from experimental systems to institutionalised national infrastructure. Major powers are co-developing, not merely procuring, LTA platforms to retain sovereign control over data, standards, and supply chains.

India is currently at a strategic inflection point either co-develop these technologies now alongside global leaders, or become dependent on imported platforms, standards, and data architectures later

Early participation will allow India to shape standards in airspace management, spectrum usage, hydrogen safety, and data governance.

Policy Recommendations

- Formal recognition of Near Space as a strategic domain within India's space and aerospace policy
- Creation of a national Near Space mission or programme, aligned with defence, disaster management, and digital infrastructure goals
- Development of a unified regulatory framework covering altitude, spectrum, safety, and data governance
- Targeted funding and procurement mechanisms for Near Space platforms under defence and civil programmes
- Promotion of indigenous materials and manufacturing supply chains
- Integration of Near Space data into national digital and AI platforms for governance and security

Investment Trends and the Deep-Tech Nature of Near Space

Global Investment Patterns: Near Space and LTA platforms are increasingly categorised as deep-tech infrastructure investments, attracting long-horizon capital, sovereign and defence-backed funding and climate and sustainability-linked investment pools

Typical investment characteristics include high upfront R&D and infrastructure costs, strong intellectual property intensity, long asset lifecycles (10–20 years) and recurring revenue models (data, surveillance, services)

Globally, cumulative investments across aerostats, HAPS, and airships already run into multi-billion-dollar valuations, particularly where platforms are linked to defence procurement or national infrastructure missions.

Sustainability and Environmental Advantages of LTA Platforms

Low-Emission Aerial Infrastructure: Lighter-Than-Air platforms derive lift from buoyancy rather than continuous thrust, resulting in very low energy consumption per unit payload, reduced operational emissions compared to aircraft and minimal ground infrastructure requirements

Airships, in particular, offer orders-of-mtrrragnitude lower carbon intensity compared to conventional air freight and heavy road transport.

Integration with Renewable Energy

Modern Near Space platforms can integrate Solar photovoltaic arrays for daytime power generation, Battery storage for night-time operation and Wind-assisted station-keeping at altitude

When combined with autonomous energy management, these platforms can operate with near-zero operational emissions, long endurance without refuelling and reduced lifecycle environmental footprint

This positions Near Space systems as green infrastructure assets, aligned with India's commitments under climate action frameworks and sustainable development goals.

Strategic Implications for National Policy

From a policy standpoint, Near Space and LTA platforms simultaneously address National security and ISR needs, Climate monitoring and disaster resilience, Green logistics and infrastructure gaps and Deep-tech industrial growth.

Few technologies offer such multi-sectoral impact with relatively modest capital investment compared to satellites or large aviation programmes.

Strategic National Benefits

- **Defence & Security**: Persistent ISR, border and coastal surveillance, early warning, and force multiplication
- **Disaster Management:** Rapid restoration of communications, situational awareness during cyclones, floods, earthquakes
- **Digital Infrastructure:** High-altitude communication relays supporting Non-Terrestrial Networks (NTN) and 5G/6G backhaul
- **Climate & Environment:** Continuous atmospheric monitoring and climate intelligence
- **Logistics & Connectivity:** Future low-emission cargo airships enabling heavy-lift transport to remote and infrastructure-poor regions

Near Space platforms unlock the future of sustainable cargo transportation, NTN-enabled digital connectivity, and persistent national situational awareness—without the cost and rigidity of purely satellite-based systems.

India's Role

Near Space is moving from experimentation to deployment globally: Advanced economies are no longer treating Near Space as a research domain; it is being operationalised for border surveillance, maritime awareness, communication relays, and logistics. Late entry would lock India into follower status.

Technology dependency risk if delayed: If India waits, future acquisition will involve Import of complete systems, Limited access to core materials, control software, and AI models and Exposure to export controls and geopolitical constraints

Standards and norms are being set now: Airspace management, spectrum usage, hydrogen safety, and data governance standards for Near Space are currently evolving. Countries participating early will shape these norms; late entrants will be compelled to comply.

Cost and time advantages favour early movers: Indigenous development today is significantly cheaper than licensed procurement tomorrow, particularly for platforms with long service lives and recurring data/service revenue models.

Strong alignment with India's deep-tech and Atmanirbhar priorities: Near Space platforms directly leverage Indian strengths in materials science, electronics, AI/ML, and systems engineering, while enabling MSME and startup participation.

Conclusion

Globally, Near Space platforms are transitioning from experimental systems to institutionalised national assets. Countries that act early will shape standards, supply chains, and export markets. For India, integrating Near Space and LTA platforms into the national space and aerospace strategy, offers a rare opportunity to build sovereign capability, lead in sustainable aerial infrastructure, strengthen defence and disaster preparedness and anchor a new deep-tech manufacturing ecosystem. This additional layer complements India's orbital achievements and ensures a resilient, multi-tier aerospace architecture for the coming decades.

Near Space and Lighter-Than-Air platforms represent a once-in-a-generation opportunity to build sovereign, sustainable, and persistent national infrastructure. India's future space leadership will depend not only on its achievements in orbit, but also on how effectively it leverages the vast atmospheric domain below. Near Space platforms and Lighter-Than-Air technologies represent a cost-effective, scalable, and

strategically vital capability that can strengthen national security, enhance disaster resilience, and support inclusive development.

By institutionalising Near Space and Lighter-Than-Air platforms today, India can build sovereign, sustainable aerial infrastructure that directly advances the objectives of Viksit Bharat 2047, while positioning India as a national hub for next-generation aerospace and deep-tech manufacturing, thereby creating a resilient, multi-layered aerospace ecosystem aligned with national priorities.

Author Note: The author is a materials scientist and aerospace technologist, and is the Co-founder and CEO of Red Balloon Aerospace Private Limited, engaged in indigenous Near Space and Lighter-Than-Air platform development, with prior experience at the Indian Space Research Organisation and Skyroot Aerospace.



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&

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CSIR- Indian Institute of Chemical Technology

(Under Ministry of Science & Technology, Govt. of India)
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CSIR-Indian Institute of Chemical Technology (CSIR-IICT), Hyderabad was established in 1944, as a constituent laboratory of Council of Scientific and Industrial Research (CSIR), Government of India. Since its inception, CSIR-IICT focussed on the development of advanced, sustainable and affordable technologies. The primary strength of CSIR-IICT is its rich pool of scientists and post docs and doctoral students. It is internationally recognised for its contributions to chemistry research and is an ideal place for taking ideas to commercialization through state of the art research and development.



For the past seven and half decades CSIR-IICT has developed globally competitive and environmentally friendly technologies in agrochemicals, pharmaceuticals, homogeneous and heterogeneous catalysts, lipids, coal, ceramics, bio-fuel, polymers, and coatings, fine chemicals, organic intermediates, environment and clean energy. More than 150 technologies developed by CSIR-IICT are in commercial productions. While several of them are transferred on lab scale that are pursued to commercialisation by the clients, CSIR-IICT has the capability to offer pilot and commercial scale development of the technologies to interested partners by providing basic engineering package and detailed design reports - end to end solutions. For eg: Hydrazine hydrate (HH) technology transferred to Gujarat Alkali Chemicals Ltd., (GACL), Toluene derivatives technologies to Vinati Organics. Further, for sustained earnings from out licensing of patents/products, preference is given to follow the revenue model with royalty for such total solutions projects. The 10000 TPA commercial plant of HH shall be in operation by middle of 2020 that substitutes imports worth of 400 crore saving on foreign exchange per annum. As part of the agreement, CSIR-IICT received license fee from GACL and also royalties on sales for a period of 5yrs from the date of commercialisation.

A couple of patents on Oroxylum indicum were out licensed to the Sami-Sabinsa Group, which manufactures and markets phytonutrients and standardized herbal extracts, specialty fine chemicals, and organic intermediates used in the nutritional, cosmeceutical and food industries worldwide. The licensed invention relates to methods of using Oroxylum indicum as a rich source for flavonoid compounds having mucoprotective and antigastric ulcer properties, and containing Oroxylin A, Chrysin and Baicalein. These bioactive molecules are used as potent alpha-glucosidase inhibitor, either as a supplement or incorporated into pharmaceuticals, food products and health foods for treating hyperglycemia (elevated glucose levels) and have great potential in alleviating the symptoms of hyperglycemia associated with diabetes, obesity and other related conditions. CSIR-IICT received license fee for transfer and also royalties on sales upon commercialisation.

Another recent success story of CSIR-IICT is out licensing of patents on a New Chemical Entity (NCE) with potential therapeutic activity across multiple indications to Sun Pharmaceuticals India Ltd. As part of the agreement, CSIR-IICT will receive upfront license fee and potential development, regulatory and sales milestone payments totalling up to Rs. 2.40 billion, plus royalties on net sales from commercialization of the products developed using these patents. Sun Pharma will be responsible for development, regulatory filings, manufacturing and commercialization of these potential products. This collaboration is aimed at clinical development of the molecule to address the unmet medical needs of patients in the long term.

CSIR-IICT holds India's largest state of the art NCE repository derived from naturally occurring products of Indian origin in the MOLBANK (Molecule Bank) located inside the campus that have huge potential to be developed in to drugs for various diseases. We will be entering in to collaborations with interested pharma companies in the near future.

Additionally, CSIR-IICT constantly provides value added services to the industry and academia, through analytical & characterization and consultancy support. To support small business houses and academia, CSIR-IICT has a discounted pricing policy for MSMEs and Universities. CSIR-IICT has a NABL accredited IEC 17025 compliant, instrumentation facility to provide better value addition to its clients. CSIR-IICT also engages in overseas collaborations for co-development through FTE's under the 'Innovate in India' initiative of GoI. Currently MoU's are in place with Australia, France, Norway, UK, etc. on advanced research areas of mutual interest. Further, MoU with African Nations (Rwanda, Ethiopia, Zambia etc,) are also in place for need based knowledge transfer in the areas of selected SDG's. Capacity building programs are taken up under the integrated skill development initiative of CSIR aligned to Skill India program of GoI with tailor made programs for government officials, graduate & Post graduate students in Bio Pharma and chemistry disciplines for synthetic and analytical skills. Incubation facilitation is extended to nurture, encourage and support the start ups and budding entrepreneurs in the area of chemistry.

Further, CSIR-IICT liaises with corporate houses to tap the CSR funds for deployment of socially relevant technologies and also collaborate on R & D projects of mutual interest in light of the recent announcement made by the Hon'ble Finance minister that India Inc can now use CSR spending on S & T and contribute to R & D collaboratively with National institutions of eminence.

CSIR-IICT has been working intensively in the area of science driven translational research and to promote R &D innovations through industrial collaborations, CSIR-IICT has established a Business Collaboration culture with the following guiding principles;

- Simple & Swift with no bureaucratic hassles
- Flexible and Transparent, and responsive to the needs of the industry
- Participative and Supportive
- Synergistic collaborations

We are indeed happy to work with industry to meet their technological requirements and provide complete solutions through either of the convenient models. viz. sponsored, collaborative, consultancy and technical services. Please visit our website (www.iict.res.in) for more details and feel free to contact me for further details.

Dr. D. Srinivasa Reddy
Director
CSIR-Indian Institute of Chemical Technology
Hyderabad- 500007, India

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INDIA INTERNATIONAL SCIENCE FESTIVAL 2025

International Advanced Research Centre for Powder Metallurgy & New Materials (ARCI)

Hyderabad - 500005, Telangana, India

Translating Research - Transferring Technology





ARCI's UNIQUE MANDATE

- Development of advanced materials and processes
- Demonstration of technologies at prototype and pilot plant scale
- Transfer of technologies to Indian industry for commercialization
- Human Resource Development

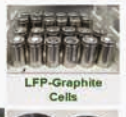
ARCI AT A GLANCE

- Spread over an area of around 100 acres with state-of-the art infrastructure
- Application oriented R&D and industry centric
- Expertise in technology development, demonstration and transfer - transferred 33 technologies to more than 48 receivers
- Provided more than 350+ technological solutions through extensive collaborations with industries/universities/R&D institutes in India and abroad.
- Providing testing and product characterization, consultancy, training as well as literature and patent search in areas of core competence
- Undertakes sponsored projects from government agencies to develop specific products and/or associated technologies, besides carrying out contract research for Indian and foreign companies

MAJOR ACHIEVEMENTS

Tropical Batteries & Advanced Materials


Know-How Transfer Agreement signing between ARCI and DashamLabs for Silica Aerogel Technology

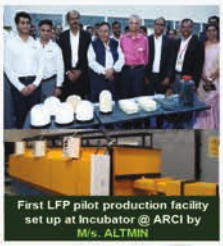

LFP-Graphite Cells

LFP-LTO Battery


Supercapacitors


Alternator (Magnetic Materials)




First LFP pilot production facility set up at Incubator @ ARCI by M/s. ALTMIN

Engineered Coating Technologies


Portable Cold Spray


CAPVD


EBPVD


Heavy duty diesel engine Pistons


Indigenously developed erosion-resistant blades


Axial plasma spray


Advanced Detonation Spray Coating (ADSC)


HVAF


Advanced coatings for Indian aero engine programs


Thermal barrier coatings

Solar Energy Materials


Perovskite Solar Cell


Solar Absorber Tubes


Parabolic trough test rig


Anti-reflective coatings on glass



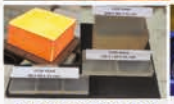
ARCI Team at Borosil

Advanced Ceramic Materials


ADITYA L1



SiC Mirror and Cold Finger Assembly


Low expansion glass ceramics (LEGC)


Spinel Domes


Antimine Boots


Waste Sanitary Napkin Incinerator

Laser Processing of Materials


Ultra fast laser micro machining


Valve Block




EBM-AM Hip Implant




Acetabular cups






Spinal cage implants


Additive Manufacturing

Laser Cladding / Hardening / Repairing

Laser Cladded Burner Tip

Laser Joining & Brazing

Fuel Cell Technology

Electrocatalysts for Fuel Cell

Electrochemical Methanol Reformer (5 kg/day-Hydrogen Production)

Fuel Cell System

Grid independent 5 kW FUEL Cell power systems

Fuel Cells Stack

Know-How Transfer Agreement between ARCI and InfiHydro for PEM Based ECMR for Hydrogen Generation

Please visit www.arci.res.in for more details

Technology Marketing: Identifying Entrepreneurs for Transfer of Advanced Materials Technologies

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The marketing of publicly funded R&D plays a crucial role in translating public research into innovations that generate economic, social, and environmental value in the marketplace and society. Technology marketing connects laboratories with industry, investors, and users, ensuring that publicly created knowledge extends beyond publications and is effectively transferred to organizations, where it is commercialized into products, services, and solutions. Accordingly, successful transfer of the developed technologies is one of the crucial indicators of its performance for a public-funded organization like the International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI). This article covers innovative practices used by ARCI and a few examples of technology transfers using such practices:

1. Innovative Practices Being Used by ARCI for Connecting Research with Relevant Stakeholders

Several initiatives, as mentioned below, have been undertaken by ARCI to facilitate the transition of technologies from the laboratory to the marketplace.

i. **Technology Assessment, Identification of Value Addition Needs, and Forging Partnerships in view of the Identified Needs:** Assessment of Technology Readiness Levels (TRLs) and the availability of complementary resources/capabilities with potential partner organizations are among the major considerations when scouting entrepreneurs for technology transfer. ARCI has been implementing these practices for several years to forge the necessary partnerships for eventual technology transfer and commercialization. Readiness Levels were developed for ARCI, taking into account the nuances of domains (originating field i.e. advanced materials technology and target applications), partnership needs for advancing in the scaling-up chain, and the lab-to-industry technology transfer.

ii. **Categorizing Technologies Available for Transfer:** The pool of technologies available at ARCI has been categorised into process-based and equipment-based technologies for crafting suitable technology transfer strategies.

Process-based technology - In process-based technology, the know-how about the process and its application is demonstrated. For instance: Anti-Reflective Coating Technology for solar photovoltaic glass. The process involves sol preparation, the coating technique, i.e., roll-to-roll coating of the glass using ARCI's sol, and curing for a sufficient period. Later, the coating performance was demonstrated at the Company's site and compared with solar glass coated using sols provided by alternative sources.

Equipment-based technology - In this case, technology transfer involves the equipment to implement the process and the process know-how to develop the identified application(s). For example, Cold Gas Dynamic Spray Coating Technology, a low-temperature thermal spray variant, involves accelerating micron-sized powder particles to supersonic velocities, resulting in the formation of dense, thick, and pure coatings with high deposition rates.

iii. **Competition Analysis / Market Research:** Our methodology entails a combination of primary and secondary research. ARCI attempts to gain incisive insights primarily regarding market sizing, potential market trends, application development scenarios, and competitive benchmarking. Some of the technologies in which such analysis was conducted include Lithium Iron Phosphate and Lithium Titanate for Li-ion Batteries, Li-ion cell manufacturing, antibacterial coating for laptops and mobile phones, Metal Additive Manufacturing for aerospace, healthcare, and other applications.

iv. **Exploring Several Channels to Publicize ARCI Knowledge-base/ Technological Capability:**A brochure is prepared mentioning key features, application areas, and the readiness level of the technology. Publicity materials, and developed applications/components, are showcased in trade shows, invited lectures are delivered in conferences, seminars, conclaves, and technology summits, to demonstrate ARCI's capabilities. In addition, business opportunity workshops are organized to further promote ARCI's expertise. In other words, awareness about available technologies is created using all possible avenues/communication channels to identify potential collaborators/technology receivers.

v. **Using Flexible Engagement Models / Contractual Agreements to Forge Meaningful Partnerships:** Confidential-cum-Non- Disclosure Agreements (CNDAs) are signed with the identified potential partners to initiate the flow of information to explore the possibility of a business relationship. Thereafter, flexible business models/contractual Agreements are being used to forge partnerships with interested industrial organizations/other stakeholders of the innovation and entrepreneurship ecosystem based on the unique commercialization needs of ongoing technological projects. These models/contractual Agreements enable partnerships at different levels of readiness (TRLs), leading to the optimum utilization of the intellectual capabilities available at ARCI.

   For example: (A) Option Agreement has been used to encourage industrial organizations/startups to field-test the developed technologies to enhance their trust in ARCI technologies before these industrial organizations/startups decide to acquire ARCI technologies for commercialization.

   (B) Cooperative R&D Agreement (CRADA) has been used to forge partnerships with appropriately identified industrial organizations to enhance the commercialization chances of early TRL technologies.

   (C) Agreements based on the GOCO Model, signed with ARCI's technology recipients, have been used to bring down the initial cost of capital/ delay fixed capital investments for technology commercializing entities. This approach, in turn, has encouraged industrial organizations/startups to attempt technology commercialization and make a convincing business case for further plans.

   (D) Technology Incubation facility (provided by ARCI's Advanced Materials Technology Incubator) is a support system for technology commercializing entities, another effort to accelerate the monetization of developed technologies.

   The above mechanisms provide novel technology commercialization opportunities to industrial organizations/startups, as well as add new verticals of value creation by ARCI to the innovation and entrepreneurial ecosystem.

vi. **Creating Costing Models in sync with the Engagement Models/Contractual Agreements**

   Costing models are continually evolving to manage the financial aspects of engagement models / associated Contractual Agreements for the implementation of various projects and technology transfers.

Technology Transfers at ARCI Effected Using Innovative Practices

By using innovative practices as mentioned above, ARCI has transferred 33 technologies to 48 receivers and has provided more than 350 technological solutions to various organizations representing industry, academia, and R&D. A few examples are mentioned below:

Silica Aerogel Flexible Sheets



ARCI signed Know-How Transfer Agreements with Dasham Labs Private Limited (DPL), a start-up, for (1) transfer of know-how on a non-exclusive basis for producing aerogel flexible sheet using the supercritical drying (SCD) method. (2) transfer of know-how on an exclusive basis for producing aerogel flexible sheets using the ambient pressure drying (APD) method. One of the Scientists involved in developing this technology will associate with the DPL as a co-founder and non-remunerative honorary scientific advisor, under ARCI's Scientific Entrepreneurship Program. Recently, ARCI completed a know-how demonstration for producing aerogel sheets using the SCD method, and the transfer of process-related know-how is expected to be completed shortly.

Proton Exchange membrane (PEM) based Electrochemical Methanol Reformer (ECMR) for Hydrogen Generation



ARCI signed a Know-How Transfer Agreement with InfiHydro Solutions LLP, a start-up, for the manufacture of PEM-based ECMR for hydrogen generation. ARCI agreed to transfer the Know-how to InfiHydro on a limited, exclusive basis valid for a period of 30 months from the date of the Agreement signing. Currently, milestones related to the in-house demonstration, along with the handing over of the know-how document, are being pursued.

Lithium Iron Phosphate (LFP) Cathode Powder Material for Li-ion Batteries



ARCI signed Technology transfer agreements with ALTMIN Pvt Ltd., Hyderabad, for making Lithium Iron Phosphate (LFP) Cathode Powder Material for Li-ion Batteries by providing i) exclusive rights for territories other than India and ii) non-exclusive rights within India. The technology transfer process has been completed.

As a significant milestone, ALTMIN established India's first pilot-scale Carbon-LFP manufacturing facility, with a capacity of 100 kg/day, at ARCI's Advanced Materials Technology Incubator (AMTI).

Antireflective (AR) Coating Technology for Solar Photovoltaic Application



The AR coating technology was transferred to Borosil Renewables Ltd. Since then, multiple industrial trials have focused on preparing the solution in bulk, optimizing its deposition with a high-throughput industrial roller coater, and ensuring the coating's durability. By fine-tuning the sol preparation and process parameters, the team achieved over 95% transmittance on commercial solar glass measuring 1 m x 2 m. The company has commercialized the technology and has been paying royalty.

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Kambhampati Suresh
Chief Sub-Editor, Eenadu

In the country's post-independence era, media played a vital role in promoting awareness on the realm of science. Eenadu, the most popular Telugu daily has been a pioneer in shaping public perspective on scientific matters. The newspaper, which is part of Ramoji Group founded by Sri Ramoji Rao, a rationalist and scientific thinker to the core. Sri Ramoji Rao's foray into the field of journalism began with Annadaata, the first ever Telugu agriculture magazine launched in the year 1969. As someone hailing from a family of farmers, Ramoji Rao thought it was his responsibility to empower the farming community by spreading awareness on scientific farming and by keeping the farmers abreast of the latest scientific developments in the field of agricultural science. Annadaata presented expert views on how to achieve high yields from crops like paddy, oil seeds, cotton, millets, lentils etc. It was a holistic farm magazine covering every aspect of farming from horticulture to fertilizer and pesticide utilization, from farm loans to marketing farm produce, from animal husbandary to dairy farming. The articles it gave on dairy farming, poultry, sericulture, irrigation management etc enriched the farmers' knowledge and nudged them towards scientific practices. For more than four decades, the magazine remained an inseparable part of farmers' lives in Andhra Pradesh as a result of its constant strivings to encourage scientific approach to farming. Considering its success in Telugu language, Annadaata was launched in other Indian languages also. As the media group expanded, Eenadu, which became the largest circulated Telugu daily within no time, ETV, a pioneering Telugu language TV channel and ETV Bharat, the digital media entity of the group, also carried forward Ramoji Rao's thinking by promoting scientific farming through columns like Ryte Raju (farmer is the king) Jai Kisan etc. Eversince its commencement in 1995, ETV - Annadaata became inseparably inter-twined with Farmers's lives as they reaped rich yields and benefited in diverse ways by following the advise it gave. Annadaata effectively carried the inventions and innovations from the farm laboratory to the farm.

Empowering the Reader with Comprehensive Science Coverage

Launched in the year 1974, Eenadu became a house-hold name among Telugu newspaper readers within no time. Right from the beginning it has been instrumental in disseminating scientific knowledge through various columns. At the time of Eenadu's launch, discussing sexual problems in the open was a taboo. It was beyond anyone's imagination to publish such problems and their solutions in a newspaper. Eenadu was the first revolutionary newspaper to introduce a column titled 'Sex Science" to promote knowledge on sexual issues. The newspaper's founder Chief Editor Ramoji Rao was of the view that lack of sexual knowledge was ruining lives due to false impressions and misconceptions on the subject. He considered it a responsibility to promote knowledge on the subject through doctor's advise, without any sexually explicit pictures accompanying it. The column was a run away hit in those days.

Apart from introducing Sex Science, Eenadu became a pioneer in the field of Telugu medical journalism by introducing a page entirely dedicated to spreading health awareness among viewers. The page titled

Sukhibhava gave features on all kinds of health related matters. This weekly presents easy to understand articles on various diseases, apart from giving tips on their prevention and treatment. This page carries interactive special columns titled Samasya - Salahaa (Medical problem and advise), Apoha - Nijam (Misconception about a disease and the reality) and Anubhava Saaram (the experiences of a doctor). This page covers all the topics related to human health. Popular medical specialists are occasionally interviewed to enlighten the readers about their fields of specialty.

The newspaper also presents a weekly Science and Technology page called E-nadu, which empowers readers with the knowledge about the developments in the field of Science and Technology. E-nadu introduces new inventions from across the World to the readers. It disseminates knowledge on digital equipment like mobile phones, laptops and computers. The page dedicates considerable space to expert articles on how different sections of the society can harness Artificial Intelligence. E-nadu is instrumental in promoting scientific temperament through its exclusive articles on the subject. From latest inventions to cyber attacks E-nadu is a comprehensive feast for readers seeking scientific knowledge.

Eenadu's science coverage on programmes like Chandrayaan was widely acclaimed. The newspaper regularly presents interviews with top class scientists from various fields. It has been in the forefront in presenting comprehensive coverage to global science developments also. When NASA launched Parker Solar Probe in the name of popular scientist Proffessor Eugene Parker, Eenadu gave the scientist's interview as a curtain raiser. On several occasions Eenadu presented exclusive interviews with Nobel Laureates like Prof. Serge Haroche, Prof. Takaaki Kajita and Prof. Ada E. Yonath.

ISRO's landmark events like Mangalyaan, Chandrayaan - 1, 2, 3, Aditya-L1 and NASA's historic missions to Mars, Sun, asteroids etc were given extensive coverage to educate the readers. Beyond astronomy and astrophysics, Eenadu also gave wide coverage on aerospace, climate change, defence technologies and biodiversity. When Hyderabad hosted UN COP11, Eenadu presented a wide variety of articles on Bio diversity and climate change.

Eenadu.net, Eenadu's digital version, also became a great source of multifarious and comprehensive science news coverage. Its Sunday magazine educated the readers with a wide variety of science related features very frequently.

ETV - Bridge between Misconceptions and Awareness

As the brain-child of Sri Ramoji Rao, ETV continues to serve as a strong bridge between the common citizen and science, and between misinformation and true awareness. The TV channel's three decades long journey demonstrated a clear resolve to make complex scientific developments accessible to the viewers in lucid and understandable language. ETV consistently presented innovations and advancements from the scientific world in a manner that inspired the Telugu audiences.

ETV has been in the forefront of presenting key scientific developments across agriculture, healthcare, space, environment, defence, and technology. In addition to science based programmes such as Annadata and Sukhibhava general programmes like Margadarshi, Cheppalani vundi, Idi Sangathi, and Yuva also frequently carried science related subjects. Science issues were seamlessly integrated into regular news bulletins also, ensuring timely and contextual dissemination.

From Nobel Prize winning scientists to grassroots level innovators emerging from rural landscapes, ETV has been presenting the awe-inspiring journeys of science warriors. Thereby it has been fulfilling its role as a true “Champion of Scientific Cause” in Telugu television journalism. Through special reports, dedicated programmes, and everyday news coverage, ETV consistently upholds rationality as its guiding principle, steering clear of anti-science narratives and advancing with a strong commitment to responsible and ethical journalism.

ETV Bharat - Redefining Digital Science Coverage

As a digital media initiative of the Ramoji Group, ETV Bharat, stands at the forefront of science and technology journalism in India. With a dedicated network of reporters across 24 states and content published in 13 languages, the platform brings ground-level stories and expert insights to a diverse national audience. Backed by six years of digital experience and the legacy of a five-decade-old media powerhouse, ETV Bharat is redefining how science and technology are communicated in the mobile-first era.

The platform excels at translating complex scientific developments into accessible narratives—whether it's breaking down ISRO's space missions, spotlighting research from IISc and IIA, or explaining the science behind everyday phenomena. ETV Bharat serves as a vital link between cutting-edge innovation and the public, inspiring curiosity and fostering scientific literacy.

The technology coverage of the publication spans a wide spectrum—from the microcosm of semi-conductors to the macro world of data centres. ETV Bharat demystifies emerging technologies like artificial intelligence (AI), augmented and virtual reality (AR/VR), robotics, and climate tech, while emphasising sustainability and ethical innovation. Through expert interviews, grassroots innovation stories, and product reviews of gadgets and laptops, the platform ensures that global tech trends reach the users in time.

By integrating science and technology into daily news cycles and special features, ETV Bharat nurtures a culture of informed engagement. With a commitment to clarity, credibility, and curiosity, it continues to inspire a deeper public connection with science and technology.



Academy for Science, Technology & Communication

2004-2025

Academy for Science, Technology and Communication

Aims and Objectives

Advancement of Science, Technology, Education, by bringing together Scientists/ Technologists/ Educationists/ Doctors/ Engineers for the purpose of diffusion of useful scientific knowledge among people.

To Organize science communication activities by disseminating information to the general public with participation of academic industrial and scientific institutions through popular lectures, seminars/ symposia, workshops, refresher courses, panel discussions etc., besides publication of books on science/ newsletter / journals etc.

To conduct periodical academic enrichment programmes, with innovative projects for promotion of science and engineering, involving teachers and students, to pursue curiosity and creativity among budding scientists and to stimulate scientific temper.

To provide an unique forum for scientific community to discuss matters of current interest, bring out publications and encourage with academic Fellowships & Awards for Excellence.

To promote temperament of Science and Technology among Youth.

*ASTC - Registered under Societies Registration Act

Academy for Science, Technology & Communication
www.astcacademy.com - E-mail: astc.academy@gmail.com

The Academy for Science, Technology & Communication (ASTC) origins trace back to 2004 when Sri S. Kapardheswer, former Assistant Director, Commissionerate of School Education, initiated a collective effort to popularize science and technology in society. Dr. J. Koneti Rao, a well-known Popular Science Writer, contributed immensely during the initial years, delivering the first lecture on "Science Communication and Scientific Temper" on 1 October 2004 at Bala Bharathi High School, Hyderabad.

ASTC was formally established with 30 founder members from various disciplines and likeminded science enthusiasts. ASTC was Registered under Societies Registration Act 2001 in the year 2004 at Hyderabad. The first Executive Council was led by Dr. C. V. Ratnavathi (DoSR-ICAR) as President and Smt. M. Nagamani (NRSA) as Secretary. Since then, the Academy has been working consistently to bridge scientific institutions, academia, policymakers, industry, and society, promoting widespread science awareness and communication.

The ASTC is recognized as a leading organization committed to cultivating scientific awareness, enhancing science communication, and advancing the dissemination of scientific knowledge to the public.

Vision & Mission

ASTC aims to advance science, technology, and education by bringing together scientists, technologists, educationists, doctors, and engineers to share and diffuse useful scientific knowledge. The Academy organizes public lectures, seminars, symposiums, refresher courses, and panel discussions and publishes communications for outreach. It supports academic enrichment, nurtures curiosity and creativity among youth, and recognizes contributions from the scientific community through fellowships and distinguished awards.





Dr. B.G. Sidhartha, Dr. K.V. Raghavan, Dr. G. Sundararajan, founder chairmen/Vice-Chairmen of Scientific Advisory Council are seen during the seminar on "Recent trends in nano-material Science" held on 26th August, 2006.





Sri J. Harinarayan, Chief Secretary, Govt. of AP seen at the National seminar "Advancing Frontiers in Geochemistry" held on 20th October, 2006. Dr. R. H. Sawkar, Secretary, Geological Society of India addressing at the National Seminar.

ASTC- Scientific Advisory Council (SAC)

The SAC plays a crucial role in guiding ASTC's programs and strategic direction.

Chairmen

Dr. Ch. Mohan Rao, Former Director, CSIR-CCMB and Dr. B. Sesikeran, Former Director, ICMR-NIN

Vice-Chairmen

Prof. P. Appa Rao, Former Vice-Chancellor, UoH and Dr. D. Raghunadha Rao, Director of Research, MNJ Institute of Oncology

Hon. President

Dr. R. B. N. Prasad, Former Chief Scientist, CSIR-IICT, Hyderabad

Key Members

Dr. G. Sundararajan (Former Director, ARCI); Prof. D. N. Reddy (Former RAC-DRDO & Former Vice Chancellor, JNTU-Hyderabad); Dr. Ahmad Kamal (Former Director, NIPER); Dr. Prakash Kumar (Director, CSIR-NGRI); Prof. K.R.S. Sambasiva Rao (Vice -Chancellor, Mangalayatan University, Jabalpur); Dr. K. Thangaraj (Former Director, CDFD); Dr. S. Venkata Mohan (Director, CSIR-NEERI); Dr. G.P. Raja Sekhar (Vice-Chancellor, Andhra University); Dr. G. Narahari Sastry (Former Director, CSIR-NEIST); Prof. S. Vijayabhaskara Rao, (VC I/c, Dr. B. R. Ambedkar Open University & Vice-Chairman, APSCHE); Dr. Vijayalakshmi Venkatesan (Movva Health Care); Dr.Ch. Sasikala (Smart Microbiological Services); Dr. K. Mruthyunjaya Reddy (Director, B.M.Birla Science Centre); Dr. M. Ghanashyam Krishna (University of Hyderabad); Dr. J. L. N. Sastry (Swasti Veda Pvt. Ltd).

Convenors

Dr. Y. Purushotham, Vice- President, ASTC & Center Head, C-MET, Thrissur and Dr. C. V. S. Kiran, CEO & Co- Founder, Red Balloon Aerospace Pvt. Ltd.





Dr. D. Balasubramanian, Director, LVPEI as the Chief Guest at the Panel Discussion on "National SSR Policy" held on 29th January, 2020. Dr. B.G. Sidharth, Chairman, SAC, ASTC presided over the program.

Executive Council - 2025

President: **Dr. C. Manikyamba,** DAE- Raja Ramanna Chair & Former Chief Scientist,CSIR- NGRI.

Vice-Presidents: **Dr. Y. Purushotham** (Center Head, C-MET, Thirussur) and
Sri M. N. V. Viswanath (Formerly NFC)

Secretary: **Sri C. L. Narasimha Rao** (Formerly APAS)

Joint Secretary: **Sri P. Srinivasa Rao** (Formerly IIOR)

Treasurer: **Sri R. R. Somayajulu** (Formerly Bank of Maharashtra)

Members:

Dr. C.V. Ratnavathi (Former Director, ICAR-IIMR)

Dr. M. Nagamani (Formerly NRSA)

Dr. C.V.S. Kiran (Co-Founder and CEO, Red Balloon AeroSpace Ltd.)

Sri R. Subrahmanyam (BMBSC)

Sri B. Srinivasa Murthy (Financial Consultant)

Sri M. Ramabhadra Rao (Kotak Mahindra Bank)





Dignitaries at the Symposium on "Women in Science" held on 19th November, 2004

Highlights of Major Activities, National Seminars & Symposia organized by ASTC

ASTC has organized numerous scientific programs impacting various sections of society. The ASTC has been making rapid strides with remarkable service to the cause of science and technology.









Hon'ble Dr. Tamilisai Soundararajan, Governor of Telangana was the Chief Guest at the "National Science Day" celebrations and ASTC Annual Convention and presenting ASTC Annual Awards on 29th February, 2020.

Dr Tessy Thomas, Distinguished Scientist and Director General of DRDO delivered the ASTC- Dr. K. V. Raghavan Memorial Lecture on February 29, 2020 at part of ASTC Annual Convention held at B.M.Birla Science Center, Hyderabad.

The pandemic opened our eyes to our deficiencies in electronic chips, among others. ASTC and the CASEST timely organized a symposium on "Electronics for Self-reliance" in collaboration with National Academy of Sciences, India (NASI) Hyderabad Chapter during February 16-17, 2023 at University of Hyderabad. The Symposium was attended by the Directors General of CSIR, DRDO, academia and industrial leaders. Prof. V. Ramgopal Rao, Pillay Chair Professor and Former Director IIT, New Delhi delivered the Key note Address in the inaugural session on "India Semiconductor Mission: How can academia leverage this opportunity?". Professor B. J. Rao, Vice-Chancellor, University of Hyderabad presided over the Inaugural Function. Dr. G. Satheesh Reddy Scientific Advisor, Raksha Mantri delivered the Valedictory Address on 'Self -Reliance in Electronics.

Similarly, while India started thinking of opening space for private entrepreneurs. The ASTC, jointly with NASI Hyderabad Chapter and the Space Federation of India, organized the seminar on "Recent Trends in the Space Sector - New India" on January 20, 2023, at CSIR-National Geophysical Research Institute (NGRI), Hyderabad. Dr. (Smt.) Tamilisai Soundararajan, the Governor of Telangana, was the

Chief Guest and felicitated the scientists. Dr. A. S. Kiran Kumar, former Chairman of ISRO, delivered the keynote address.

ASTC is providing a platform with excellent opportunities for experts to exchange ideas, establish collaborations and more importantly ignite the young minds.

ASTC organised Women Scientists Meet on different occasions and the Women Scientists Conclave held on 10th October 2022 held in Vivekananda Auditorium, at CSIR-IICT. The event was inaugurated by Dr Tamilsai Soundararajan, Hon'ble Governor of Telangana and her inspiring address motivated the young researchers.











Dr. Tamilisai Soundarajan, Hon'ble Governor of Telangana as the Chief Guest at the Women Scientists Conclave held at Vivekananda Auditorium, CSIR-IICT on 10th October, 2022.





Scientific gathering on the Earth Day Celebrations on 22nd April, 2024 inaugurated by Smt. Vani Prasad, IAS, Principal Secretary, Energy Environment, Science and Technology, Govt. of Telangana.

ASTC organised "Earth Day celebrations- Meet Geo Scientists on 22nd April 2024. The event was inaugurated by Smt. A. Vani Prasad IAS, Prl. Secretary to Govt. of Telangana. Padma Sree Dr H.K. Gupta was the Chief Guest. Dr. S. Venkata Mohan CSIR-IICT delivered Earth Day Lecture.

Padma Bhushan Dr Vikram Sarabhai 105th Celebrations in Association with coinciding with the National Remote Sensing Center on 12th August 2024

Dr. Tamilisai Soundarajan, Hon'ble Governor of Telangana as the Chief Guest at the Seminar on "Recent Trends in Space Sector" held at CSIR-National Geophysical Research Institute on 20th January, 2023. Dr. A.S.Kiran Kumar, former Chairman, ISRO and Dr. M. Ravichandran, Secretary, MoES, Govt. of India are also seen. Dr. Prakash Chauhan, Director, NRSC and Dr. Rajeev Jyoti, Director-Technical, INSPACe are also seen along with dignitaries on the dais.





















Eminent Doctors' participation at the National Doctors' Day Celebrations held on 1st July, 2024. Dr. D. Nageshwar Reddy delivered Bharat Ratna Dr. B.C. Roy Memorial Lecture on "Doctor and Society" on 1st July, 2024 at B.M. Birla Science Centre, Hyderabad.

ASTC and B.M. Birla Science Centre organized National Doctors' Day celebrations on July 1, 2024, commemorating Bharat Ratna Dr. B.C. Roy's birth and death anniversary at Bhaskara Auditorium, BMBSC. Dr. D. Nageshwar Reddy, Founder and Chairman of Asian Institute of Gastroenterology & AIG Hospitals, Hyderabad delivered the "Bharat Ratna Dr. B.C. Roy Memorial Lecture" and felicitated doctors from various fields who participated as panel speakers in the discussion on "Common Health Issues - Solutions in Medicine."



Dr. B.K. Das, Director General-ECS, DRDO inaugurated the symposium on "Electronics for Self-Reliance" held on 16th-17th February, 2023 at the University of Hyderabad. Dr. V. Ramgopal Rao, Pillai Chair Professor and Fr. Director, IIT Delhi delivered the Keynote Address. Dr. N. Kalaiselvi, Director General, CSIR delivered the Prof. S. Bhagavantam Memorial Lecture. Dr. G. Sateesh Reddy, Scientific Advisor to Raksha Mantri delivered the Valedictory Address on 17th February, 2023 at University of Hyderabad.

ASTC jointly with Andhra University, Visakhapatnam organized a Science Conclave on "Science & Technology Frontiers for Swarnandhra and Viksit Bharat @ 2047" on 5th September 2025 commemorating Teachers' Day, at the Andhra University, Visakhapatnam. The event was held as part of the year-long Centenary Celebrations of Andhra University and also marked a Golden Year Tribute to Bharat Ratna Dr. Sarvepalli Radhakrishnan, former President of India and former Vice-Chancellor of Andhra University. The Conclave was conducted. Padma Shri Prof. Sanghamitra Bandyopadhyay, Director, Indian Statistical Institute, Kolkata, graced the occasion as the Chief Guest and inaugurated the Conclave. Prof. G.P. Raja Sekhar, Vice-Chancellor of Andhra University introduced the thematic sessions celebrating the contributions of pioneering scientists and technologists. Dr. Prakash Chauhan, Director, National Remote Sensing Centre (NRSC), delivered the Distinguished Lecture on "Indian Space Programme for Societal Benefits: A Game Changer for Viksit Bharat".

Prof. B.S. Murty, Director, IIT Hyderabad, delivered the Prof. Suri Bhagavantam Memorial Lecture on the theme "Role of Higher Education Institutions in Viksit Bharat" on 5 September 2025 at the Andhra University Convention Center, Visakhapatnam.

Prof. G. Narahari Sastry, IIT Hyderabad and Former Director, CSIR-NEIST, Jorhat, delivered the Dr. K. V. Raghavan Memorial Lecture on "Emerging Drug Discovery Technologies" on 5th September 2025 at the Andhra University, Visakhapatnam.

Dr. D. Raghunadha Rao, Founder Director, Homi Bhabha Cancer Hospital, Visakhapatnam, delivered the Dr.Yellapragada Subba Rao Memorial Lecture on "Artificial Intelligence for Public Health". on 5th September 2025 at the Andhra University Convention Center, Visakhapatnam.

Dr Yellapragada Subba Row Memorial Function Lecture Series was held on 25th January, 2025 at Narasapur, native district of Dr Subba Row. These lectures were delivered by Dr Ch. Mohan Rao, Former Director, CSIR-CCMB on 'Modern Biology and Medicine' and Dr. D Raghunadharao, President of the Andhra Pradesh Akademi of Sciences and Dr D. Leela President Indian Society for colposcopy and Cervical Pathology on "Cancer: Its Prevention and Screening"

Prominent lecture series include those dedicated to:

Dr. Mrutyunjay Mahapatra, Director-General, India Meteorological Department (IMD), delivered the Padma Bhushan Dr. P. Koteswaram Memorial Lecture on 5th September 2025 at the Andhra University Convention Center, Visakhapatnam.

Dr. B. K. Das, Outstanding Scientist & Director-General - Electronics & Communication Systems (ECS), DRDO delivered the ASTC - A. S. Rao Memorial Lecture on "Leveraging Defence R&D for Atmanirbhar Bharat" on 16 February, 2023 at University of Hyderabad.

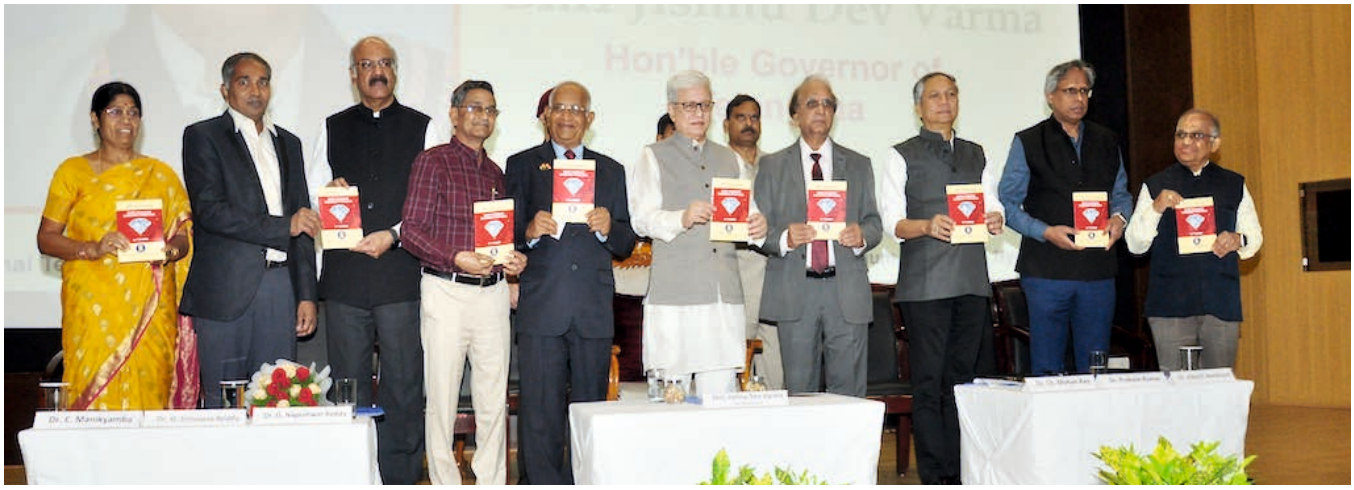
Dr. Suma Varughese (Director- General, DRDO) delivered Dr. K. V. Raghavan Memorial Lecture at the ASTC Annual Convention held on 10th October, 2022, at the Vivekananda Auditorium, CSIR-IICT, Hyderabad.

National Technology Day Celebrations and ASTC Annual Convention were held on 11th May, 2025 at Vivekananda Auditorium, CSIR-IICT. Sri Jishnu Dev Varma, Hon'ble Governor of Telangana was the Chief Guest along with Pabma Vibhushan Dr. D. Nageshwar Reddy and Directors of CSIR Laboratories.









Hon'ble Governor of Telangana, Sri Jishnu Dev Varma released three issues of "ASTC COMMUNICATIONS" on 11th May, 2025

ASTC Annual Convention and Annual Awards – Flagship Recognition

Presented during the ASTC Annual Convention in the presence of distinguished Guests.
















ASTC-Lifetime Achievement Awards

2024:

Padmabhushan Dr. A. V. Rama Rao (AVRA Labs); Padma Bhushan Dr. D. Nageshwar Reddy (AIG); Dr. J. M. K. Murty (Care Hospitals); Dr. Ch. Mohan Rao (CCMB); Prof. P. Appa Rao (UoH)

2025:

Dr. B. Soma Raju (Sindhu Hospitals); Dr. D. Raghunadha Rao (MNJ Institute of Oncology); Dr. D. N. Reddy (Former V.C,JNTU-H); Dr. M. Narayana Rao (Formerly MIDHANI); Dr. G. Satheesh Reddy (Former Chairman DRDO); Dr. Ahmed Kamal (Formerly, NIPER and CSIR-IICT)

ASTC-Excellence Awards in S & T

2024:

Dr. K. P. C. Gandhi (Formerly CFSL); Dr. V. Chandrasekhar (TIFR); Prof. B. S. Murty (IIT-H); Dr. Sanjay Sinha (Apollo Hospital)

2025:

Dr. N. Manjula Reddy (CCMB); Dr. D. Srinivasa Reddy (CSIR-IICT); Dr. Prakash Chauhan (NRSC); Prof. K. R. S. Sambasiva Rao; Dr. S. V. S. Narayana Murty (ACMD, MIDHANI); Prof. G. P. Raja Sekhar (Andhra University); Dr. S. Venkata Mohan (CSIR-NEERI)

Science Popularization Awards

2024:

Dr. K. B. Gopalam (Popular Science Writer)

2025:

Sri Pallava Bagla (NDTV); Sri M. Soma Sekhar (Business line); Dr. C. V. Sarveswara Sarma (Popular Science Writer); Sri Suresh Kambhampati (EENADU); Smt. Ratna Chotrani (Science Writer)

ASTC-Honorary Fellowship

ASTC Honorary Fellowship Certificates were presented for significant contributions in S&T and Communication by the Guest of Honour Padma Vibhushan Dr. D. Nageshwar Reddy, Chairman, AIG Hospitals.








National Space Day celebrations were held on 22nd August 2025 jointly with VFSTR at Guntur. Dr.Pavuluri Subbarao Chairman and Managing Director,(CMD) Ananth Technologies Ltd (ATL) was the Chief Guest. During that event, it was decided to launch the **Andhra Pradesh Space Tech Academy (AP Space Tech Academy),** a pioneering initiative to nurture the next generation of space scientists, engineers, entrepreneurs, and leaders and this was the first-of-its-kind initiative to nurture future space scientists, engineers, and entrepreneurs. **Dr. V. Seshagiri Rao Former Distinguished Scientist SHAR , Sriharikota; Dr. Ch. Venkateshwar Rao Former, Additional Director-General, Geological Survey of India and Dr I.V. Muralikrishna, DRDO Raja Ramanna Chair Professor delivered Expert lectures**





ASTC in association with Andhra University organized the Science Conclave on 5th September, 2025 at Vishakhapatnam. Prof. V. Raja Shekhar, Vice Chancellor, Andhra University addressed the gathering and felicitated distinguished scientists

ASTC confers Honorary Fellowships upon scientific Community to build stronger academia-industry partnerships, enhance the knowledge ecosystem, and inspire national scientific progress aiming to Strengthen ASTC's academic foundation, Foster academia–industry partnerships, Promote scientific engagement through seminars, lectures, and community outreach and Broaden expert participation in ASTC's national activities.

Accordingly, to mark its two decades of service to science communication, ASTC has decided to present the Honorary Fellowships recognizing senior professors, scientists, technologists, and medical professionals who have contributed significantly to research, innovation, and public scientific engagement representing leading universities, national laboratories, and scientific institutions across India.

The Academy proudly conferred Honorary Fellowships upon 97 academicians on the occasion of its Annual Convention organised coinciding with the National Technology Day and these fellowships were presented by the Guest of Honour Padma Vibhushan Dr. D. Nageshwar Reddy, Founder Chairman, AIG Hospitals on 11th May,2025 at the Auditorium, Indian Institute of Chemical Technology, Hyderabad.

ASTC LIST OF HONORARY FELLOWS

S.NO	NAME	INSITIUTE
1.	AHMED KAMAL	CSIR-Indian Institute of Chemical Technology
2.	ALTHAF HUSSAIN K	Mahatma Gandhi University
3.	ANILKUMAR CHALAMALASETTY	GREENKO
4.	APPA RAO P	University of Hyderabad
5.	BABU T M	Geological Survey of India
6.	BALARAM V	CSIR-National Geophysical Research Institute
7.	BHANUPRAKASH REDDY G	ICAR-National Institute of Nutrition
8.	CHAITANYA SWARUP	Zilla Parishad High School
9.	CHANDRASEKHAR V	Tata Institute of Fundamental Research Hyderabad
10.	CHETTY T R K	CSIR-National Geophysical Research Institute
11.	CHIRANJEEVI T	KIMS Sunshine Hospital, Hyderabad
12.	DASAVANTHA REDDY V	Centre for Plant Molecular Biology, Osmania University
13.	DEVENDER KUMAR	CSIR-National Geophysical Research Institute
14.	DEVLEENA MANI TIWARI	Centre for Earth, Ocean and Atmospheric Sciences, University of Hyderabad
15.	GANDHI K P C	Central Forensic Laboratory
16.	GEETA K VEMUGANTI	School of Medical Sciences, University of Hyderabad
17.	GEETA RAO	Administrator - G P Birla Centre
18.	GHANSHYAM KRISHNA M	School of Physics, University of Hyderabad
19.	GOPALAM K B	All India Radio (AIR)
20.	GUPTA H K	CSIR-National Geophysical Research Institute
21.	HARINARAYANA T	CSIR-National Geophysical Research Institute
22.	JALEEL M A	Kamineni Hospitals
23.	KAISER JAMEEL	CSIR- Indian Institute of Chemical Technology
24.	KALACHAND SAIN	CSIR-National Geophysical Research Institute
25.	KAPARTHESWAR RAO	Directorate of School Education, Government of AP

26.	KRISHNA MURTY G	Central Ground Water Board
27.	KRISHNA RAO D	CSIR- Indian Institute of Chemical Technology
28.	KUSUMITA ARORA	CSIR-National Geophysical Research Institute
29.	LABANI RAY	CSIR-National Geophysical Research Institute
30.	LAKSHMI B	
31.	LEELA D	St. Theresa Hospital
32.	MAHADEV P	Pharma Industry
33.	MALLA REDDY P	Kakatiya University
34.	MANIKYAMBA C	CSIR-National Geophysical Research Institute
35.	MANORAMA S V	Centre for Cellular & Molecular biology
36.	MOHAN RAO CH	Centre for Cellular & Molecular biology
37.	MRUTHYUNJAYA REDDY K	National Remote Sensing Centre
38.	MURTY A S N	CSIR-National Geophysical Research Institute
39.	MURTY B S	IIT Hyderabad
40.	MURTHY J M K	Care Hospitals, Hyderabad
41.	NAGAMANI M	National Remote Sensing Agency (NRSA)
42.	NAGESHWAR REDDY D	AIG Hospitals
43.	NANDAN M J	CSIR-National Geophysical Research Institute
44.	NARAHARI SASTRY G	CSIR- Indian Institute of Chemical Technology
45.	NARASIMHAN C	Apollo Hospitals
46.	NARAYANA RAO M	Nuclear Fuel Complex, Hyderabad
47.	PRAKASH KUMAR	CSIR-National Geophysical Research Institute
48.	PRASAD R B N	CSIR- Indian Institute of Chemical Technology
49.	PRATIBHA NALLARI	Osmania University
50.	PURUSHOTHAM Y	Centre for Materials for Electronics Technology (C-MET)
51.	RADHA V	Centre for Cellular & Molecular biology
52.	RADHADEVI P V	Advanced Data Processing Research Institute (ADRIN), Hyderabad
53.	RAGHAVENDRA RAO BONDADA	Chairman & Managing Director, Bondada Group
54.	RAGHUNADHA RAO D	MNJ Institute of Oncology
55.	RAIDU N V	Apollo Hospitals
56.	RAJKUMARI INDIRADEVI DHANRAJGIRI	Hyderabad
57.	RAJENDRA PRASAD L	Vishakhapatnam Steel Plant
58.	RAMADEVI C	Bharatiya Vidya Bhavan, Hyderabad
59.	RAMAKRISHNA B V	Acharya Nagarjuna University
60.	RAMMOHAN RAO P	AP, Fisheries Department
61.	RAMANA K V	National Remote Sensing Centre (NRSC)
62.	RAMA RAO A V Padma Bhushan	AVRA Laboratories
63.	RAMESH K V	Gitam University
64.	RAVI RAJA P	Astronomical Society for Training, Research and Out-reach (ASTRO)
65.	REDDY D N	Osmania University

66.	RATNAVATHI C V	ICAR-Indian Institute of Millets Research (IIMR)
67.	SARVESWARA SARMA	Konaseema Science Parishad
68.	SAMBASIVA RAO K R S	Mangalayatan University
69.	SAMBAMURTHY D	Ophthalmologist
70.	SANDEEP KUMAR GUPTA	CSIR-National Geophysical Research Institute
71.	SANJAY SINHA	APOLLO Hospital
72.	SASTRY J L N	Jata's Health Care
73.	SATYANARAYANAN M	CSIR-National Geophysical Research Institute
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75.	SESHIKIRAN B	ICAR- National Institute of Nutrition
76.	SHAILAJA D	CSIR- Indian Institute of Chemical Technology
77.	SHYAM KOTHARI	Secretary, GP Birla Archaeological Astronomical and Scientific Research Institute
78.	SIDHARTH B G	BM Birla Science Centre
79.	SRINIVASA RAO G	National Remote Sensing Centre
80.	SREEBHUSHAN RAJU	Nizam's Institute of Medical Sciences
81.	SUBBA RAO R V	Bhabha Atomic Research Centre (BARC)
82.	SUBRAMANYAM R V	BM Birla Science Centre
83.	SUNDARA RAJAN G	International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI)
84.	SUNDARAM CHALLA	Nizam's Institute of Medical Sciences
85.	SUJATHA M	ICAR- Indian Institute of Oil Seeds Research
86.	SUNITA REDDY N	APOLLO Hospitals
87.	SWARNALATHA	CSIR- Indian Institute of Chemical Technology
88.	TESSY THOMAS	Defence Research and Development Organisation
89.	THANGARAJ K	Centre for Cellular & Molecular biology
90.	VENKATA MOHAN S	CSIR- Indian Institute of Chemical Technology
91.	VENKATESHWAR RAO CH	Geological Survey of India
92.	VIJAYA RAO	CSIR-National Geophysical Research Institute
93.	VENKATESHWARI A	Institute of Genetics, Osmania University
94.	VIJAYALAKSHMI VENKATESAN	ICAR-National Institute of Nutrition
95.	VIJAYABHASKARA RAO S	Sri Venkateswara University, AP
96.	VISWANATH M N V	Nuclear Fuel Complex, Hyderabad
97.	YADUKRISHNA R R	CSIR- Indian Institute of Chemical Technology

ASTC–COMMUNICATIONS

Knowledge sharing remains central to ASTC's mission. The Academy has published seminar proceedings on themes such as Recent Trends in Nano-Material Science and Advancing Frontiers in Geochemistry through Utilization of Earth Resources, and is further expanding its publishing initiatives. A new publication series titled "ASTC–COMMUNICATIONS" has been launched to deliver crisp, accessible booklets on contemporary scientific topics to wider audiences.

The first three issues were released by Shri JishnuDev Varma Ji, Hon'ble Governor of Telangana on the National Technology Day on 11th May 2025 on the following topics:

1. More Kohinoor Diamonds from India — Authored by Dr. T. M. Babu
2. Oils and Fats for Health and Nutrition: Myths and Facts — Authored by Dr. R. B. N. Prasad
3. The Sun and Solar Energy: Igniting the Future — Authored by Dr. T. Harinarayana

The following two more issues are under process and will be released in the month of January, 2026.

1. Gas Hydrates: A Potential Clean Energy Source for India — Authored by Dr. Kalachand Sain
2. A handbook on Cancer, Screening and Prevention — Authored by Dr. D. Leela and Dr. D. Raghunadharao

This series will continue to expand across major thematic domains in science, technology, and health communication.

Expression of Gratitude

ASTC acknowledges the unwavering encouragement, collaboration, and voluntary contribution extended by individuals and leading scientific organizations. Their support has enabled the Academy to execute impactful national programs and outreach initiatives for over two decades. Notably, all major activities have been carried out without any government funding, reflecting ASTC's strong community spirit, collective commitment, and its mission-driven approach aligned with global scientific standards.

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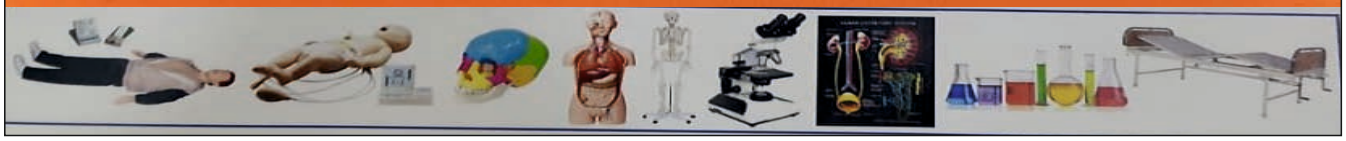
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CSIR-National Environmental Engineering Research Institute) (CSIR-NEERI), Nagpur

CSIR-National Environmental Engineering Research Institute (CSIR-NEERI) is playing a very significant role in the field of environmental science and engineering. The Institute is dedicated to the service of mankind by monitoring the environmental status, across the country and providing innovative and effective S & T solutions to environmental and natural resource problems. CSIR-NEERI has been instrumental in keeping a check on environmental degradation by conducting vital R&D activities in the field of environmental science and engineering. A host of environmentally sound technologies being developed at CSIR-NEERI will help in reaching a goal of sustainable development.

Major R&D Areas

Environmental Monitoring

Environmental monitoring is a core R&D thrust of CSIR-NEERI, with the Institute operating a nationwide air quality monitoring network since 1978. Through long-term programmes supported by CPCB, CSIR-NEERI has generated invaluable air quality datasets for major Indian cities and developed expertise in monitoring ambient, industrial, vehicular, and stack emissions. The Institute also undertakes air quality modelling, source apportionment, trend analysis, and design of air pollution control systems, along with the development of analytical techniques, low-cost instruments, national databases, and capacity building.

Environmental Biotechnology and Genomics

CSIR-NEERI carries out multidisciplinary research in environmental biotechnology and genomics to develop sustainable, eco-friendly solutions for environmental protection and resource recovery. Its work spans bioremediation of contaminated sites, wastewater treatment, waste-to-wealth technologies, and climate change mitigation. Using advanced genomic tools, the Institute studies microbial diversity and ecosystem functions, enabling scientific management of air, water, soil, and biological systems through integrated monitoring, modelling, and simulation approaches.

Environmental Impact and Risk Assessment

CSIR-NEERI plays a vital role in integrating environmental, social, and economic considerations into developmental planning through environmental impact and risk assessment studies. The Institute has conducted assessments for over 700 major projects across sectors such as energy, infrastructure, mining, petrochemicals, and ports. These studies support informed decision-making by identifying potential impacts, assessing risks, and recommending effective mitigation and environmental management measures for sustainable development.

Environmental Systems Design & Modelling

The Institute is actively engaged in the development and application of numerical models, GIS, and remote sensing tools for prediction and management of environmental quality and natural resources. CSIR-NEERI also provides detailed engineering designs for water supply, sewerage, and wastewater treatment systems, supported by advanced analytical, numerical, and

visualization tools. These capabilities enable integrated environmental systems analysis, planning, and management.

Water Technology and Management

CSIR-NEERI undertakes comprehensive R&D in water resources assessment, conservation, and management, covering surface water, groundwater, and drinking water quality. Its expertise includes performance evaluation of water and wastewater treatment plants, contamination assessment, advanced water quality monitoring, and remediation of degraded water bodies and lands. Notably, the Institute's solar-powered electrolytic defluoridation technology has provided safe drinking water solutions in fluoride-affected regions across India.

Solid & Hazardous Waste Management

CSIR-NEERI has made significant contributions to sustainable solid and hazardous waste management through technologies for waste minimization, recycling, composting, waste-to-energy, and secure landfill design. The Institute undertakes waste characterization, eco-toxicological studies, landfill gas monitoring, and remediation of contaminated sites. Its nationally recognized interventions, including mercury site remediation and industrial waste management solutions, demonstrate its leadership in environmentally sound waste management.

Wastewater Treatment, Recycle and Reuse

CSIR-NEERI has played a pivotal role in the design, commissioning, and performance evaluation of Common Effluent Treatment Plants and industrial wastewater treatment systems across the country. Through innovative, cost-effective technologies such as two-stage bio-oxidation, electro-oxidation, and High Rate Transpiration Systems, the Institute supports pollution prevention, zero liquid discharge, and resource recovery. These solutions have delivered significant environmental, economic, and social benefits to industrial clusters nationwide.

Environmental Policy Analysis

CSIR-NEERI supports national environmental governance through policy analysis aligned with international commitments and socio-economic priorities. The Institute provides evidence-based recommendations on policy, legal, and planning frameworks, promotes cleaner production technologies, and develops information packages for sustainable industrial practices. CSIR-NEERI also assists regulatory authorities and courts by providing expert reviews, inspections, and evaluations of environmental policies and projects.

Technologies developed and deployed

Air pollution monitoring & control

1. NEERDHUR-Multifuel Improved Cookstove: zero-maintenance, multi-fuel cookstove with efficient combustion, lower emissions, faster cooking, and improved safety.
2. Green Firecrackers: with reduced emissions, noise, and harmful chemicals.
3. Green Crematoria: offer cleaner, faster cremation with reduced emissions, lower firewood use, improved air quality, and safety.

4. NEERI-KSHAN-AQ-UAV-based vertical air pollution profiling system: enables cost-effective, multi-height, remote air quality monitoring, plume tracking, and model validation.

Wastewater

5. High Rate Transpiration System (HRTS): enables efficient, low-cost wastewater treatment with minimal land, energy use, and carbon sequestration.
6. Municipal waste water treatment using immobilised microbial culture (Bioculture): uses immobilized microbes to efficiently reduce BOD, COD, and pollutants.
7. Automatic Mechanical Urinal Toilet Flusher: hygienic, user-friendly toilet with ultra-low water use supporting open defecation free (ODF) objectives.
8. Upflow Compact Constructed Wetland (UCCW): chemical-free, gravity-based wetland system providing complete multi-stage wastewater treatment.
9. Renewable Hydropower from Drain / Rivulet Outlet (ReHyDRO): harnesses drain/rivulet flow using a compact, portable turbine for sustainable, cost-effective green energy.
10. Low Temperature Adapted, Methanogenesis (LTAM) Process: uses cold-adapted microbes for low-cost, compact, decentralized low-temperature wastewater treatment.
11. The Himalayan STP (Him-STP): provides low-cost, cold-adapted biological treatment for sustainable sewage in Himalayan regions

Water

1. RISK PiNET Software: identifies, quantifies, and visualizes risks, supporting quantitative risk assessment, QRA, planning, and informed decisions.
2. IOT based dashboard for water quality monitoring: enables real-time GIS-based monitoring of water services, integrating sensor data and RISK-PiNET analysis.
3. NEERZAR- Instant water filter: portable, lightweight water filter removing turbidity, solids, and microbial contaminants efficiently.
4. Hand pump attachable iron removal plant: efficiently removes 1–30 mg/L iron, providing safe water for communities

Waste Management

1. Eco- Rejuvenation Technology: restores degraded land, improving water quality, soil health, and pollutant biodegradation sustainably.
2. Compact Faecal Sludge Separation and Treatment (CFSST): separates and treats faecal sludge, enabling safe discharge and resource recovery.
3. Compact Organic Manure Processing Output (CNCOMPO): processes household organic waste into compost using controlled microbial aerobic biodegradation technology.
4. Mechanical Dewatering & Drying System (MDDS) for faecal sludge & septage management (FSSM): dewaters and dries faecal sludge, eliminating pathogens and enabling resource recovery.
5. Faecal D'FAST - Bacterio-Bio-Chemical Formulations for Decomposition of Faeces, Faecal Sludge and Sewage Solids and it's Preparation

Vision for Viksit Bharat 2047

CSIR-NEERI envisions playing a transformative role in realizing Viksit Bharat 2047 by advancing science-led, inclusive, and sustainable development. Through cutting-edge research, indigenous technology development, and evidence-based policy support, CSIR-NEERI aims to safeguard environmental quality while enabling economic growth, resource efficiency, and climate resilience. The Institute will continue to strengthen national capabilities in clean air, safe water, waste-to-wealth, circular economy, and ecosystem restoration, while fostering innovation, capacity building, and stakeholder partnerships. By integrating environmental sustainability with technological excellence and societal well-being, CSIR-NEERI aspires to contribute decisively to a self-reliant, resilient, and environmentally secure India by 2047.



It gives me immense pleasure to extend my best wishes on the occasion of the National Conclave on "Lab to Society: Science Communication for Shaping Viksit Bharat @2047". Effective science communication is the vital bridge that connects research laboratories with society, ensuring that scientific knowledge translates into informed decisions, sustainable technologies, and societal well-being. CSIR-NEERI remains committed to advancing this mission by fostering dialogue among scientists, policymakers, educators, students, and the public, and by promoting responsible, inclusive, and impactful dissemination of science. I am confident that this Conclave will inspire meaningful collaborations and innovative approaches to science communication, thereby strengthening the role of science and technology in shaping a resilient, self-reliant, and environmentally sustainable Viksit Bharat by 2047.

Dr. S. Venkata Mohan

Director, CSIR-NEERI

MIDHANI

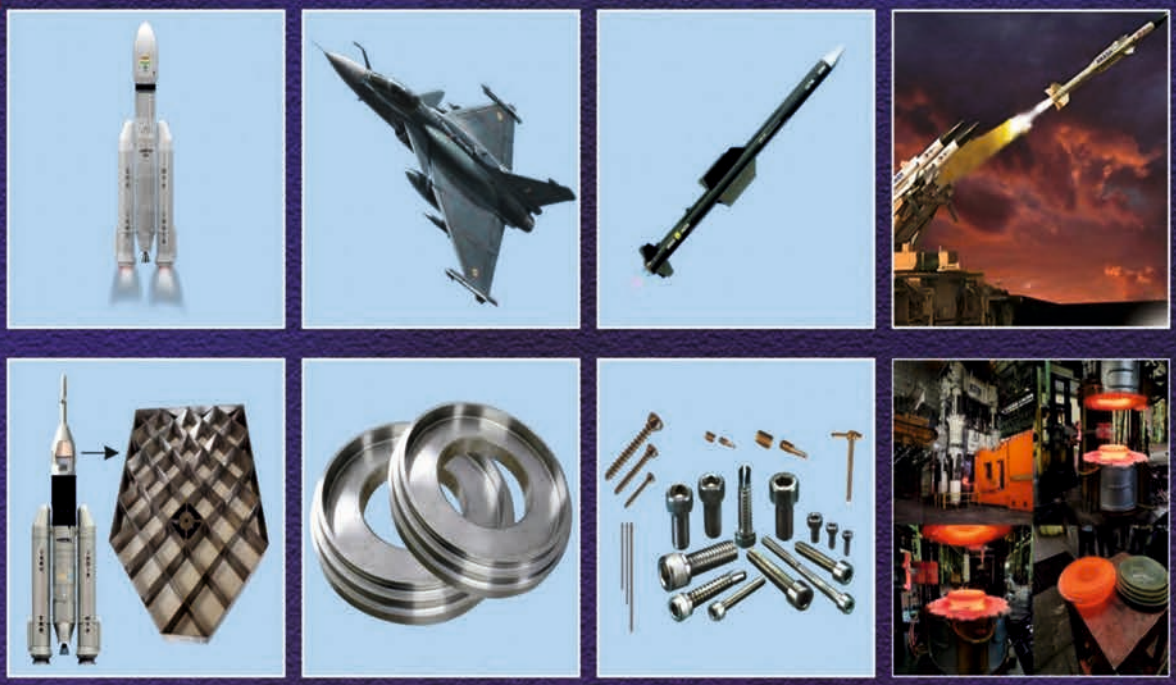
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