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Science Diplomacy

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This science digest is open to new ideas, valid criticism and constructive feedback. If there is any science diplomacy/ policy related event which requires wider outreach, please share it with us. We welcome your articles/ feedback/ suggestions at scidip@niscpr.res.in

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Editorial //////////////////////////////////////

India, the current holder of the G20 Presidency, has taken a significant step towards ensuring an effective global collaboration towards sustainable development. One of the vital groups working towards this objective is Science 20 (S20), a group of scientific advisors to the G20 countries. Established during Germany's Presidency in 2017, the S20 Engagement Group comprises international experts who work together to provide science-driven recommendations to policymakers through consensus-building. The S20 focuses on identifying critical issues in science and technology (S&T) that must be addressed to achieve sustainable development goals. This year's S20 theme is "Disruptive Science for Innovative and Sustainable Development", which highlights the need for disruptive technologies, such as artificial intelligence, quantum computing, smart materials, and meta materials, in tackling complex societal problems.

Considering the various activities being organised as a part of S20, the first article in this issue discusses the potential of disruptive science in creating a sustainable future. The article highlights the crucial role of science diplomacy, which employs S&T as a means for international collaboration and diplomacy, in promoting sustainable development. One example of successful international collaborations in S&T is the establishment of institutes of national importance in India, such as the Indian Institutes of Technology (IITs), Indian Institute of Science (IISc) and the Birla Institute of Technology and Science, Pilani (BITS, Pilani). These institutes were established through collaborations between India and other countries, which led to the exchange of knowledge, resources, and expertise.

The International Advanced Research for Powder Metallurgy and New Materials (ARCI) is India's most extensive bilateral cooperation program in S&T with the erstwhile Soviet Union. The second article discusses the journey of ARCI and highlights its contributions to India's scientific and technological advancement. Another article focuses on international collaboration in astrophysical sciences in India and its significance, particularly about the Aryabhata Research Institute of Observational Sciences. The article provides insights into the research being conducted at the institute and highlights its contributions to the field of astrophysics.

India's Council of Scientific and Industrial Research (CSIR) is driving the latest developments in S&T in the country. In particular, CSIR is developing technologies with significant potential for commercialisation and export to foreign countries. Here, two such technologies, the 'Hydrazine Hydrate Technology' from the Indian Institute of Chemical Technology (CSIR-IICT) and 'Thoxcat ES™' from CSIR-Indian Institute of Petroleum (CSIR-IIP) in collaboration with Bharat Petroleum Corporation Limited (BPCL), have been covered in the present issue.

Overall, these articles showcase the importance of international collaboration in promoting scientific and technological advancement and achieving sustainable development goals. Such partnerships facilitate the exchange of knowledge, resources, and expertise and pave the way for innovative solutions to complex problems. The last two articles are on the Accademia Nazionale dei Lincei, one of the oldest and most prestigious science academies in Italy and on the G20 Research and Innovation Initiative Gathering Conference on Materials for Sustainable Energy.

We hope that our esteemed readers will find the latest issue of the *Science Diplomacy* informative and insightful. We look forward to your valuable feedback and comments.

Monika Jaggi

Towards Global Scientific Modernity Science 20 in India and its Science Diplomacy Discourse

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Our collective sense of global modernity is based on our shared sense of scientific, technological, and innovative advancements. Science and technology have democratised our shared habitation on the planet and led to greater accessibility and comprehensiveness, transcending power and privilege disparities to reach even the most remote users. Despite this progress, the world exists in different eras, including pre-modern, modern, and post-modern periods, which coexist with cohesion and discord. We require better structures to strengthen cohesion and resolve discord. This need for better frameworks, is the birth of dialogue and the foundation for discursivity that establishes a sustained possibility of discourse. I like to think of

it in terms of an interesting Foucauldian discursion where one dialogue leads into another – a continuum.

Science20 or S20 is a meeting of the academies – one can look at this platform as the coming together of vast international networks in science for a diplomatic dialogue wherein our collective future holds the central fort. In the periphery are the dynamics of cooperation and industrial translations of these cooperations. Collectively, a comprehensive debate emerges generating ideas essential for the development of civilisation.

S20 aims to provide policymakers with research-grounded recommendations based on broad consensus on selected issues of global relevance. Coordinated by the host academy, all member academies' representatives and decision-makers engage in lengthy discussions to reach a consensus statement. The host nation's G20 chair presents this statement to the Heads of Government. The signatory science academies have worked together in an outstanding spirit of cooperation and collaboration over the past six years to create a common policy document for the G20 leaders to accept and execute. The S20 group bears the crucial responsibility to engage with all stakeholders in the spirit of collective foresight and cooperation and to find solutions to the multitude of challenges faced by humanity.

Previous S20 Summits have addressed themes such as 'Improving Global Health: Strategies and Tools to combat Communicable and Non-Communicable Diseases' (Germany 2017), 'Food and Nutrition Security: Improving Soils and Increasing Productivity' (Argentina 2018), 'Threats to Coastal and Marine Ecosystems, and Conservation of the Ocean Environment - with special attention to Climate Change and Marine Plastic Waste' (Japan 2019), 'Foresight: Science for Navigating Critical Transitions' (Saudi Arabia 2020), 'Pandemic Preparedness and the Role of Science' (Italy 2021), and 'Recover Together, Recover Stronger' (Indonesia 2022).

To facilitate more productive and timely policy dialogue, it is crucial to have a comprehensive understanding of the global landscape of science. This understanding can be fostered through gatherings and conversations, which can then serve as the foundation for informed policy discussions.

The global experience of the scientific frontier is far more localised in terms of exchanges and engagement in the information age than ever before. 21st-century infrastructure has facilitated the expansion of international scientific networks connecting individuals both formally and informally to large collaborations in a shared ecosystem that supports and strengthens our knowledge systems. There has also been an exceptional rise in the informal research sector globally. Private enterprises, start-up ecosystems and independent individuals are making considerable contributions to research and knowledge systems but are represented indirectly through formal platforms.

The scientific enterprise faces challenges in the information age due to the age-old debate about intellectual narrative in public discourse. Science and society, though closely related, often come at crossroads, creating opportunities for effective dialogue. As we navigate our collective memory of the global scientific experience and our vision for its future, making decisions within the human institutions and their experiences is a challenge that requires global dialogue.

During the pandemic, we have witnessed the nature of complex questions that science must answer in a very short time to save the world. We are asking more fundamental questions with unprecedented rigour and precision. Science is now being judged based on its consequences and not just its intentions. There is no other world that seems to be waiting for us, the dialogue and diplomacy is our only pathway to making a better world.

We must now see science as a global unifier that can bring peace and security without further creation of borders or injunctions. It has proven to be effective and inclusive. Method or the logical framework of scientific inquiry engages in dialogue with all possible pathways involved in the mechanism to arrive at a theory. Logic, like a stoic wise old sage, is irrefutable, and if challenged, there are well-defined consequences. Despite that, the new age has also seen an unusual rise in irrational and unsubstantiated ideas debated in public discourse that have contemporaneously caused prejudicial friction among several factions of social and intellectual hegemony. Despite this, the new modernity of our age keeps emerging and advancing.

The emergence of global modernity is closely linked to scientific disruption and the pursuit of sustainable development. This year's Science20 conference is focused on exploring how disruptive science can lead to sustainable development. The conference will be centred around three major topics: clean energy and energy transition; the creation of holistic health that is universal; and how science, with its undisputed entanglements with society and culture, be more effective and benevolent in its relationship with them. Thus, under the overarching theme of *Disruptive Science for Sustainable Development*, we have three subthemes: *Clean Energy for Greener Future*, *Universal Holistic Health*, and *Science for Society & Culture*.

With disruptive science for sustainable development, we conceptually refer to the use of scientific innovations and advances to create more sustainable forms of economic and social development by reducing environmental impact, increasing efficiency in resource utilisation, and improving human well-being. Disruptive science uses cutting-edge technology such as data analytics, artificial intelligence (AI), machine learning (ML) and Internet-of-Things (IoT) devices, etc., which can optimise energy production and consumption; develop new renewable sources of energy; identify pollution sources; manage water supply systems; monitor air quality; optimise waste management processes; forecast weather patterns more accurately; maintain agricultural productivity levels, among others.

Disruptive science also promotes public policy changes relating to socioeconomic issues such as income inequality, poverty reduction strategies, access to healthcare services, access to finance opportunities or education reform initiatives. Furthermore, it encourages investments in green infrastructure which generate clean energy while protecting local ecosystems. Disruptive science has the potential to revolutionise how we live our lives by creating a future built on sustainability rather than the exploitation of resources. Now let's look at the subthemes in some detail.

Clean Energy for Greener Future

Our current reliance on fossil fuels is unsustainable, and we must prioritise transitioning to renewable energy to avoid catastrophic consequences, including the melting of Antarctica and an estimated 58-meter sea level rise that could displace millions living in coastal regions. Fortunately, the potential for harnessing renewable energies is enough to avert this fate - but capturing, converting and storing them on a large scale requires a monumental effort that has yet to be accomplished.

One option which should be explored when aiming for improved efficiency in our use of energy is technological advancement; however, implementing such improvements will require stringent regulations that place costs on carbon emitters and reduce price barriers associated with renewable sources like solar, wind, hydropower and biomass fuel. To this end, various technologies are being developed which offer real potential when it comes to utilising clean sources of energy. Examples include electric cars powered by batteries instead of petrol or diesel fuel; light-emitting diodes (LEDs) which consume less electricity than traditional lighting methods; plus high-voltage direct current transmission systems capable of transferring electrical power over large distances without needing transformers or other costly equipment. Despite their reliance on scattered natural resources like sunlight or wind velocity – both difficult to predict – these solutions still hold great promise in terms of technological innovation regarding both solar power generation and efficient storage solutions.

Despite our incapacity when it comes to predicting complex phenomena accurately, it is still crucial that each individual strives towards creating a better future through understanding and commitment. Acknowledging potential futures ranging from disastrous to idealistic, humanity must work together to create new energy systems compatible with long-term survival despite limitations and boundaries set by nature.

Universal Holistic Health

Universal holistic health emphasises comprehensive approaches that address physical, mental, social and environmental factors impacting health. It includes providing access to healthcare services and resources, as well as creating social and environmental conditions for healthy living. The World Health Organisation (WHO) supports this approach as part of its Health 2020 framework.

Creating better global health would not only mean creating better medical infrastructure or ease of access to medical care but also adopting sustainable practices, which would help enhance cumulative global health standards. It would mean better farming practices, availability of good food, healthy eating practices, and better opportunities for sustainable and environmentally responsible food products. In addition to this, it is important to revisit traditional practices and find a way to include them in our modern daily lives.

Holistic medicine considers the whole person- body, mind, spirit, emotions and others, for achieving an optimal state of well-being. Universal holistic healthcare ensures equal access to quality care for all individuals, regardless of economic status or geographic location, reducing disparities in health care. Additionally, emphasising preventive measures like immunisation campaigns and smoking cessation can lower the incidence rates of specific illnesses and medical costs.

Furthermore, addressing aspects like nutrition and activity levels can contribute to a general improvement in public well-being, which could eventually result in a rise in individual productivity within these countries' workforces.

It would also be ideal if cutting-edge healthcare technology were made accessible through worldwide research collaboration, establishing a network between global academia and business. In recent years, data have also become increasingly important in decision-making. With accurate measurements in place, it is crucial to evaluate how data, AI and ML technologies might be used to apply disruptive science to build a worldwide holistic health ecosystem.

Connecting Science to Society

Since the beginning of the reason-based discourse, science has struggled to find its place in the civilisational dynamics across the globe. Despite its potential to provide solutions to everyday problems and uncover the mysteries of the universe, science has not always been integrated into a cultural dialogue or social governance. It is rather amusing to observe that social evolution necessitates scientific progress and exploits scientific and technological advancements for its utilitarian purposes.

To facilitate progress, it is necessary to connect science with society and fulfil societal needs through equitable and sustainable development. It requires sharing quality scientific information with society on issues such as health, agriculture, climate change, ocean health, biodiversity loss and other areas of vital importance. A global diplomatic discourse needs to find a place in the realm of cultural diplomacy for science and its encouragement through various social engagement programs.

To promote global civilisational and evolutionary processes, it is vital to create a more interactive and inclusive science infrastructure through collaborations and partnerships. Encouraging participation in megascience projects can lead to the democratisation of scientific prowess and generate equitable benefits for all involved parties.

It is essential to position science in a public forum where it may be judged and scrutinised by the general population. Global welfare enterprises need to improve the lives of the last user through scientific and technological breakthroughs, demanding innovation that stimulates economic growth. This might be accomplished, for instance, by creating cooperative and shared incubation centres that utilise the STI capabilities of member institutions. Another significant expansion of the worldwide science diplomacy enterprise might be the promotion of entrepreneurial skills and the creation of possibilities for mentorship for science and technology-based companies.

The future of science is bright, and international cooperation will be crucial to our advancement. By forming alliances with other nations and organisations, we can use our combined knowledge to improve fields like technology, energy, and medicine in ways that would not be possible individually. We can find answers that could help humanity on a global scale by pooling our resources and sharing our knowledge. Importantly, these partnerships offer worthwhile chances for cross-cultural learning and idea exchange. When we work together across borders to foster an environment of creativity and collaboration, the future of science holds immense promise.

Institutional Diplomacy////////////////////////////////////

International Scientific Collaborations driven by Indian Science Diplomacy: The Journey of ARCI, Key Takeaways, Challenges and Opportunities

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Introduction

Science Diplomacy is an umbrella term often used to portray the international collaborations aimed at the formal or informal exchanges in science, engineering and technology to understand or address local or global issues. It is exciting and noteworthy that International Advanced Research for Powder Metallurgy and New Materials (ARCI) emerged as India's most extensive bilateral cooperation programme, the Integrated Long Term Programme (ILTP) on Cooperation in Science & Technology with the erstwhile Soviet Union. In the context of Science Diplomacy, it is essential to understand the overall journey of ARCI, right from its conceptualisation, objectives, the role of various stakeholders, continued journey to foster international collaborations with many other partners across the globe, portfolio of technologies inherited, accompanied challenges, present status and plans. All the aforementioned aspects are briefly covered in this article to highlight and appreciate the vital role of Science Diplomacy in the modern Indian context.

Science Diplomacy: Never Before in the Field of Materials

On 8 March 1988, an agreement was inked between India and the Soviet Union to establish the *Indo-Soviet Advanced Research Centre (ARC) for Powder Metallurgy* as a collaborative project with the Belarusian Powder Metallurgy Association (BPMA) to be implemented by the Defense Metallurgical Research Laboratory (DMRL), Hyderabad. Subsequently, on 15 October 1990, ARC was registered as a society in Andhra Pradesh, India. Owing to the political developments in the Soviet Union in the early 1990s, a multilateral agreement was signed with Commonwealth of Independent States (CIS) countries in 1993, and independent collaborations with republics like Russia, Ukraine, Moldova, and Uzbekistan were established in various areas of material technologies. Consequently, ARC was renamed 'International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI)' – as it is known today – on 21 March 1994.



Signing of multilateral contracts with CIS countries



Nurturing the Newborn

With the completion of the project phase in 1995-96 and attaining a physical entity, ARCI became operational as an autonomous institution of the Department of Science and Technology (DST) with its motto of

"Translating research to technology" and transformed into one of the best materials-based application-oriented research laboratories in the country. Although the initial motivation was to develop and demonstrate powder metallurgy applications to the automotive sector, ARCI gradually evolved over the years to complement a wide range of materials and processes in line with international developments and national needs.

Conforming to its unique mandate, ARCI has selectively hosted the technologies and associated processing equipment received from the CIS countries, such as horizontal and vertical Detonation Spray Coating, single and multiple electrodes holding Electro-spark Coating, Micro Arc Oxidation, Wire-arc Spraying, High Velocity Oxy Fuel Spraying, Hydrodynamic Compaction, Blue dust (Iron ore fines) reduction, Stainless Steel Filters, Self-propagating High Temperature Synthesis, Exfoliated Graphite and a variety of oxide and non-oxide ceramic product manufacturing and others. It may be noted that some of the key technological instruments were fabricated locally and the process expertise was provided by the collaborating institutions. These technologies were broadly classified into three different pillar groups, namely (a) Powder Metallurgy, (b) Surface Engineering and (c) Ceramic Processing. Quickly realising the fact that there exists a gap between what could be readily offered and what the industry requires, ARCI vigorously pursued multi-directional R&D activities to understand the technological features and product performance aspects.

Utilising the aforementioned technologies as its primary basket, ARCI has gradually reoriented itself from an otherwise typical semi-production facility into an excellent R&D laboratory by way of indigenising each of the aforesaid technologies, benchmarking it with locally and globally available products, organising the industry workshops, demonstrating the technological and economic benefits, scale up to the industrially relevant levels, preparing the prototype systems and eventually transferring many of these technologies to a large number of Indian industries.

In the above context, the vital role of international collaborations in establishing ARCI, continued support and periodic exchange of experts as supported by International Cooperation Division at DST is the most critical factor behind the success of ARCI in translating the technologies to the Indian industry demands. At the same time, the vision, guidance and support rendered by DST, the Chairman and an expert panel of Governing Councils of ARCI and Technology Advisory Groups pertaining to each Centre of Excellence as constituted by DST, together with the dynamic and able leadership (Directors) of ARCI also played an equally important role in transforming the outcome of Science Diplomacy into the low hanging fruits readily needed for the Indian industry.

Success Seeding the New Challenges

As a common phenomenon to any R&D laboratory, such as ARCI, engaged in translational research with technology commercialisation as its primary target, it is apparent that the rate at which the developed technologies are transferred to the industry is directly proportional to the pace at which its technology basket gets dried up. Keeping this in mind, driven



Dr K. Kasturirangan on pedal-powered hydrogen demo kit



Change of Guards: Dr G. Sundararajan (centre), Dr G. Sundaresan and Dr Y.R. Mahajan (left and right, respectively)



Dr A.P.J. Abdul Kalam at INDOSIS-1996 workshop



Dr V.S. Arunachalam (second from left) during a visit to ARCI

by its strong desire to be at the forefront of the developments in materials and materials processing technologies and their effective industrial use, ARCI forayed and expanded consistently, establishing new groups of excellence in application-relevant fields such as (a) Nanomaterials and coatings, (b) Laser processing of materials, (c) Fuels cells, (d) Solar energy materials, (e) Automotive energy materials and (f) Additive manufacturing. Accordingly, several in-house R&D programs were initiated to continuously feed the technology basket of ARCI at an appropriate interval. In addition, the scout for entirely new technologies (in the Indian context) but available elsewhere on the globe at various Technology Readiness Levels (TRLs) is continued not only as a means of filling the basket and delivering various national missions but also to keep the new technological and global market avenues open to the Indian industries.

Striking new international collaborations

While continuing its in-house development of materials/products/processes that the Indian industry needs, in line with its core values to work on application-centric and innovative technologies, ARCI has initiated several international collaborations with the support of DST. A few of the selected international collaborations, objectives and accomplishments are briefed below:

A joint centre for advanced nanomechanical characterisation (ANC) was established at ARCI in collaboration with **Ms. Nanomechanics Inc., Oak Ridge, USA**, in 2016. Its primary objective is to perform fundamental and applied research in small-scale mechanical characterisation that enables the development of novel test methodologies and next-generation nanomechanical testing products. The centre aims to leverage the expertise of the US partner in equipment design and ARCI in test methodology and application development. As a part of the joint centre, multiple types of equipment were sold to academic institutions, R&D laboratories, and private companies across the country. A significant achievement of the centre is the collaborative development of a high-speed nanoindentation-cum-data deconvolution tool, NanoBlitz3D+, to determine the mechanical properties of constituent phases of multi-phase materials. It was globally launched in 2019 in San Antonio, Texas, USA, during the TMS exhibition by Dr G. Padmanabham, Director, ARCI. The high-speed capability of the mapping tool has reduced the testing time for a single test from minutes to less than a second, thereby significantly



Shri Y.S. Rajan inaugurating DSC technology transferred to an entrepreneur



Dr G. Sundararajan signing a contract with ICEBT, Ukraine



Various heat pipe heat sinks produced by an entrepreneur on a commercial scale



Ultrafast Laser micromachining facility at ARCI (50- 100 fs, 800, 400 & 266 nm, and 100 ns, 527 nm, at 10 kHz) and the 3-D control grid created using such system



Simolayer Zoz-ARCI demonstration facility created at ARCI formalising alliances

increasing the throughput. The commercialisation of this tool has resulted in a paradigm shift in indentation testing at a global level, as evidenced by the 100s of research articles published using the tool. In addition to product development, many applications also progressed. Subsequently, the product and application development efforts were amply supported by basic R&D studies, resulting in more than 25 publications with 100s of citations within a few years.

Furthermore, an ultrafast laser micro/nano fabrication and machining facility was established in the Centre for Laser Processing of Materials in 2014 through a collaborative research agreement between ARCI, India, and the **National Research Council, Canada**. This activity aims to establish a state-of-art ultrafast laser processing system and develop surface texturing of materials for automotive applications. The ultrafast laser micro/nano machining system at ARCI is equipped with some of the most cutting-edge features. This system can machine features as small as 10 μm with accuracies of 0.1 μm and without heat-affected zones. In the last few years, this system has demonstrated various applications and many others are under development.

The heat pipe is an efficient heat transfer device that works on the evaporation and condensation of fluid inside the pipe and enables to transfer large quantities of heat with a minimum temperature drop. The thermal conductivity of heat pipes is several hundred times more than copper. These devices have applications in electronic, semiconductor, electric locomotive and manufacturing industries. ARCI has developed the technology for manufacturing heat pipe heat sinks of various types in collaboration with the **Powder Metallurgy Research Institute and Luikov Institute of Heat and Mass Transfer, Minsk, Belarus**. The technology was transferred to an entrepreneur, and the industry has established a manufacturing plant for heat pipes in Hyderabad.

A joint demonstration Centre for high-energy ball mill (Simoloyer) technology was established at ARCI in 2008 in collaboration with **Zoz GmbH, Germany**. The latter is a pioneer in developing high-energy ball mills, which are being used for the development and production of nanostructured materials, oxide dispersion-strengthened alloys, electrode materials for batteries, metal matrix composites, etc. Zoz GmbH supplied CM-08 mill (1 kg/batch) at a discounted price, and ARCI extended infrastructure and manpower for demonstrating the equipment to various Indian industries. Eventually, ~5 mills were sold to various Indian industries and research institutes, which earned substantial revenue for ARCI. These mills are being extensively used by ARCI, for the development of materials needed for various projects of strategic, R&D and industrial requisites.

In addition to the aforementioned international collaborations, ARCI fostered some unique technologies in the national context, namely (a) Electron Beam Physical Vapor Deposition Technology established in collaboration with the **International Center for Electron Beam Technology (ICEBT), Paton Electric Welding Institute, Ukraine**, (b) Cold Gas Dynamic Spraying in collaboration with the **Institute of Theoretical and Applied Mechanics (ITAM), Novosibirsk, Russia**, and (c) Sol-Gel coating techniques in collaboration with **EPG, Germany**, to name a few. These unique technologies are being extended to Indian strategic and industrial sectors for reaping the potential techno-economic benefits.

Summary and Way Forward

While ARCI fruitfully enjoys a multitude of success stories, arising both out of multiple products delivered and technologies transferred to Indian industries, it continues to explore all the possible avenues to invent, incubate and collaborate strategies for continued leadership in translational research. Being a direct product of Science Diplomacy per se, ARCI will continue its relentless efforts to conceptualise and systematise national and international collaborations for the benefit of Indian industry and to leap participation in various national mission programmes of the Government of India. Concerning Indian Science Diplomacy, this article clearly illustrates the fact that the current Indian ecosystem, excellent infrastructure, and receptive and yet vibrant mindset of the citizens in the country are in favour to create and nurture more institutes,

industries and startups. Accordingly, frontier areas that need immediate attention shall be identified and carefully chosen (including semiconductors, hydrogen economy, aerospace, electric mobility, advanced manufacturing and others), and Indian Science Diplomacy to act in front to forge vital collaborations for the larger benefit of present and future generations of the country to realise the global leadership in the decade to come.

As a concluding remark, Science Diplomacy is already proven to be an exceptional tool in the hands of any nation with a promise to deliver an impactful contribution to the circular economy and political and cultural development. In the current era, Science Diplomacy shall be treated as a powerful weapon that will not create any victims but drives the multi-directional growth of the nations with a promise to transform the developing countries into developed nations by way of creating healthy and wealthy societies around them.

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Institutional Diplomacy //////////////////////////////////////

A Glimpse of International Cooperation in Astrophysical Sciences in India

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Astronomy and Astrophysics is an observational science dealing with celestial objects. Aryabhata Research Institute of Observational Sciences (ARIES) is one of the premier institutions in astronomy and astrophysics and has contributed significantly to strengthening India's position in this field. No doubt, India is a part of several mega-science projects in the domain of Astronomy and Astrophysics, such as the Thirty Meter Telescope (TMT); Square Kilometer Array (SKA) and Laser Interferometer Gravitational-wave Observatory (LIGO) projects. India's growing engagement with mega-science projects has brought a positive impact on its science and technology (S&T) landscape.¹ A few such collaborations are briefed below.

The Nainital 79/51 cm Schmidt Baker-Nunn (BN) camera

From July 1957 to December 1958, a collaborative scientific program, the International Geophysical Year (IGY), was conducted to study the earth and its environment. IGY was sponsored by the International Council of Scientific Unions and involved nearly 30,000 scientists from over 70 countries, including India. It led to several significant scientific findings, including the discovery of the Van Allen radiation belts, defining of mid-ocean submarine ridges, the exploration of outer space, the construction of earth satellites, and increased research in the Arctic and Antarctic polar regions. IGY demonstrated the ability of all nations to work together harmoniously for the welfare of human endeavour. India contributed greatly to several IGY scientific activities, including optical photography of the artificial Earth satellites against the starry sky background. For this, the Smithsonian Astrophysical Observatory, United States of America (USA) installed twelve 79/51 cm Schmidt BN cameras along with a precision timing system² as part of a global network located in Argentina, Australia, Curacao, Iran, India (Nainital), Japan, Peru, Spain, South Africa and USA (New Mexico, Florida, Hawaii). Over 45,700 satellite transits, including those of India's Aryabhata and Apollo-11, 12 and 17 of the USA, were successfully recorded from Nainital.³

The Udaipur Solar Observatory and Global Oscillation Network Group (GONG)

The GONG is an international project for a detailed study of solar internal structure and dynamics using helioseismology. Therefore, a network of six extremely sensitive and stable solar velocity imagers was

installed at the Udaipur Solar Observatory in India; the Big Bear Solar Observatory in California, USA; the Mauna Loa Observatory in Hawaii, USA; the Learmonth Solar Observatory in Western Australia; the Observatorio del Teide in the Canary Islands and the Cerro Tololo Inter-American Observatory in Chile. Their longitudinal locations allow the GONG network to make 24/7 continuous observations of the Sun's "five-minute" oscillations. GONG project has been operational since October 1995 with the participation of about 175 individual members from over 20 nations, including India⁴ and being implemented and coordinated by the National Solar Observatory's Integrated Synoptic Program, USA. Such international collaborations enable long-duration continuous observations that immensely help in examining the sun's variability.⁵

Indo-Belgian collaboration

ARIES hosts four telescopes of apertures 1.04 m, 1.3 m, 3.6 m and 4 m. The latter two are 'Indo-Belgian' telescopes. The Devasthal site (Longitude = 79°41'04" E, Latitude = 29°21'40" N and Altitude = 2424±4 m), identified as a potential astronomical site for locating modern optical telescopes, became an Observatory in the year 2010 when 1.3 m Devasthal fast optical telescope (DFOT) started observing celestial objects. The 3.6 m Devasthal Optical Telescope (DOT) was successfully installed in 2015 and technically activated on 30 March 2016, jointly by the premiers of both countries, India and Belgium.³ In April 2022, a 4 m International Liquid Mirror Telescope (ILMT) was established for the first time in India to observe the celestial bodies. This new telescope is designed and built by an international consortium from Belgium, Canada, India, Poland and Uzbekistan.⁶ An aerial view of the Devasthal Observatory is shown in Figure 1.



Figure 1. Devasthal Observatory hosting the (a) 1.3 m DFOT building with the sliding roof (bottom right) and rectangular building of the 4 m ILMT (bottom left), and (b) 3.6 m DOT near the adjacent Devasthal temple.

The Belgo-Indian Network for Astronomy and Astrophysics (BINA) was created to increase academic interactions between Indian and Belgian astronomers and engineers so that modern observing instruments for Devasthal telescopes can be developed jointly.⁷ The third BINA workshop was held recently from 22 to 24 March 2023 in India. Several young and established researchers from both countries have benefitted from this collaboration. Overall, it has been an excellent example of diplomacy in science.

Ongoing ground-based mega observational facilities and challenges

The Indian astronomical community is participating in many international mega-science projects.¹ For instance, the TMT Observatory is being built by an international consortium of five countries, namely Canada, China, India, Japan and USA. TMT will be one of the world's advanced ground-based optical, NIR, and mid-infrared observatories since it – using cutting-edge global technology – will integrate the latest innovations

in precision control, segmented mirror design, and adaptive optics.⁸ Another mega project in this field is SKA - earth's largest next-generation radio telescope project. This project is funded by an international collaboration of more than a dozen countries, including India. The design of the SKA has recently been completed with the active participation of Indians. It has now entered the construction phase.⁹

The LIGO-India is another mega-science project. Once operational, it will establish a state-of-the-art advanced LIGO gravitational wave observatory on Indian soil in collaboration with the LIGO laboratory in the USA.¹⁰ All these ground-based observational facilities are unique and complementary to each other and are essential for making Indian astrophysical science globally competitive. However, these mega-projects are marred by various challenges such as large size (physical), long timelines, massive costs, credit sharing issues, and cost and time uncertainties.¹

Space-based Indian Observatory

India's first multiwavelength astronomy satellite, AstroSat, was successfully launched on 28 September 2015. In this space mission, national efforts were supplemented with international contributions from United Kingdom and Canada. It provided new bridges for global collaboration in the field of space astronomy. A few upcoming Indian space projects are summarised by Sreekumar and Rao,¹¹ including the Indian spectroscopic and imaging space telescope (INSIST)¹² and Daksha, a broadband high-energy all-sky mission.¹³ All these Indian space missions are a product of international collaborations and are good illustrators of using diplomacy in science.

Impact of international collaborations in the area of Astrophysical sciences

From Indian Observatories, mostly celestial objects in the northern hemisphere are seen, while for proper understanding of the Universe, observations of both northern and southern hemisphere objects are essential. To overcome this, various global collaborations led by the author studied northern star clusters using observational facilities of Indian observatories, while southern star clusters and of Magellanic Clouds were studied using observations taken from Australia and Chile.¹⁴⁻¹⁶

Another example is the study of rapidly oscillating A-peculiar (ROAp) stars. Out of the 31 ROP stars known till 1997, only three were discovered in the northern hemisphere. To investigate this big difference in the known ROP stars in the two hemispheres, a survey programme named Nainital–Cape Survey was initiated in 1997 at Nainital. Under this international collaboration, northern and southern hemisphere objects were observed from Nainital and Cape Town, respectively. A few years of observations discovered 4 δ Sct pulsating variables and a ROP northern hemisphere star.³

Indian astronomical observatories (Longitude $\sim 79^\circ$ E) are located in the middle of $\sim 180^\circ$ longitudinal gap between the Canary Islands ($\sim 20^\circ$ W) and Eastern Australia ($\sim 160^\circ$ E), having modern astronomical observational facilities. Consequently, they play a crucial role internationally as the observations which are not possible from both these countries due to daylight or other reasons can be taken from the Indian observatories or vice-versa, as demonstrated above. Such Indian observations have contributed to many discoveries, including time-domain astronomy, e.g., studies of Gamma-Ray Burst (GRB) afterglows and variable sources which require 24 h continuous monitoring. The extended ring system around Uranus was discovered with a combination of quality observations taken from Kavalur and Nainital in India; Cape Town in South Africa; Tokyo in Japan, and Western Australia during the occultation event of SAO 158687 by Uranus on 10 March 1977. In the same way, under international collaborations, Indian multiwavelength observations of GRB afterglows support the core collapse model for the progenitor of long-duration GRBs and put observational constraints on the popular progenitor's models of short-duration GRBs.^{3,17} All these illustrate the importance of international collaborations in Astronomy and Astrophysics.

In the future, India may take the initiative to collaborate with neighbouring countries like Afghanistan, China, Hong Kong, Nepal, Pakistan, Singapore, Thailand and Uzbekistan, etc., to utilise their available expertise and resources optimally.

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CSIR Success Story

Indian Academia-Industry Collaboration in Developing Novel Process for Hydrazine Hydrate

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The process technology for Hydrazine Hydrate (HH) is highly desired in India. The CSIR-Indian Institute of Chemical Technology (CSIR-IICT) achieved a breakthrough in developing the HH technology indigenously in close association with a premier industry partner, Gujarat Alkalies and Chemicals Limited (GACL). The technology comes in the purview of Make-in India, Sashakt Bharat and Atmanirbhar Bharat initiatives.

Applications of Hydrazine Hydrate

Segment	Percentage
Polymerisation and Blowing Agents	35%
Agrochemicals	20%
Water Treatment	25%
Pharmaceuticals	8%
Others	12%

Import Substitution

Due to India's reliance on imports for 100% of HH, there was a pressing need to substitute this valuable chemical product with a domestic alternative. However, international collaboration was not an option, as the countries manufacturing HH were solely interested in selling the product and did not offer the necessary technology. Compounding the issue, the plant in India that previously produced HH through the urea route had ceased production and closed its operations.

In response, innovative solutions were developed to address knowledge gaps and overcome scientific and technical challenges in the creation of an eco-

friendly process. By partnering with manufacturers of intermediates, who currently rely on imports, it is possible to achieve direct sales of up to 70% of the HH production capability (about 7000 tons).

Highlights

- The developed process differs from others in terms of its energy efficiency and environmental friendliness.
- Able to recover, regenerate, and reuse solvents and key raw materials without any loss in yield and conversion.

- High-purity product specifications meet international standards.
- Zero effluent generation.
- Commercially viable process.

Innovation

- HH technology is developed for the first time in India through an indigenous improved process route. Other manufacturers of HH are LANXESS, Arkema Group, Lonza, Weifang Yaxing Chemical Co. Ltd. and Otsuka-MGC Chemical Company, Inc.
- The process developed *via* the peroxide-ketazine route is novel and superior to other routes, such as the urea route, because it avoids hydrazine decomposition, consumes less ammonia, and produces high yields with minimal effluent generation.
- The process adopted a pressure reactive distillation for carrying out the hydrolysis reaction for the production of 40% HH, resulting in an 85% yield of high-purity product. The product was concentrated to 80% HH using simple distillation. The present route of production of 80% HH is a green process with any effluent water generated was treated chemically, biologically, and with membrane processes for reuse. The product meets international norms for impurities, making it marketable for export.
- Experiments conducted at bench scale – 100 g/h were successfully tested for yields, conversions, properties' data and operability. The process was scaled up to 12 kg/h. A pilot plant was designed and successfully commissioned/operated for more than a year. The pilot plant aided in data collection for the design and engineering of the 10000 TPA HH commercial plant, which is constructed at GACL Dahej Complex, Gujarat, in association with Larsen & Toubro (LTTE), Mumbai, which is the EPCM (Engineering Procurement Construction Management). Around 400 kg of HH was produced in the pilot plant, which was sent for seed marketing of the product that met international specifications.

Process Development

- The process was scaled up to a pilot scale of 12 kg/h. A pilot plant was designed and successfully commissioned/operated for more than a year.
- Around 400 kgs of HH was produced in the pilot plant, which was sent for seed marketing of the product that met international specifications.
- The pilot plant aided in exploring the design and engineering data generation for the 10,000TPA HH commercial plant.
- The commercial plant construction is completed at GACL, Dahej Complex, Gujarat, and process trial runs are in progress.

Scale-up

Scale-up was done for standardisation of process and steps, recoveries, recycle studies, data collection for the design of the commercial plant from lab to bench scale and bench scale to pilot scale and final commercial scale design.

Advantages

- The indigenous technology, the first of its kind in India, to have a commercial plant of substantial capacity.
- GACL leverages its in-house production of key raw materials, including hydrogen peroxide and ammonia from its sister company, giving it a competitive advantage.
- The technology developed is on par with global standards and practised by international players.
- The investment in the technology promises a reasonably attractive payback period of 5-7 years.

Patents

Joint Patents Granted, with our Industry Partner:

- Indian Patent No. 378643 Dated 05 Oct 2021 - An Improved Process For Production Of Hydrazine Hydrate; Applicants: Council of Scientific & Industrial Research, New Delhi (IN); Gujarat Alkalies and Chemicals Limited, Gujarat (IN).
- United States Patent No. US 11,225,413 B2 (45) Dated 18 Jan 2022 - Process For Production Of Hydrazine Hydrate; Applicants: Council of Scientific & Industrial Research, New Delhi (IN); Gujarat Alkalies and Chemicals Limited, Gujarat (IN).

Export potential

GACL's strategic location near Middle Eastern and African countries provides it with an advantage for exporting HH. The company can compete with manufacturers from China and Europe in terms of pricing and quality. However, at present, India needs all its HH production for domestic use, and there are no plans to export the technology.

Market Demand

- HH has a huge market demand, and the technology will open a new chapter in India for its usage, as the country has previously relied entirely on imports.
- The global HH market value is expected to grow rapidly and cross US\$784 million by 2033.
- Asia-Pacific is one of the largest markets for HH, with the maximum consumption from countries, such as China, South Korea and India.
- The mandate to produce HH is also to meet the growing demand of manufacturing azodicarbonamide required as a foaming agent in the polymer and plastic industry.
- HH finds applications in the manufacture of pesticides and some value-added chemicals in the pharma industry.

The above factors are expected to drive the HH market in the next decade.

Commercial plant overall picture:

- Plant capacity: 10,000 tons per annum of 80% HH
- Annual Turnover: 300 crores per annum (@Rs. 300/- per kg of HH)
- The cost of the commercial plant is around Rs. 405 crores.
- ROI is 5–7 years.

Plant construction and mechanical commissioning are completed. Process trial runs are in progress. Commercial production is expected between March 2023 to June 2023.

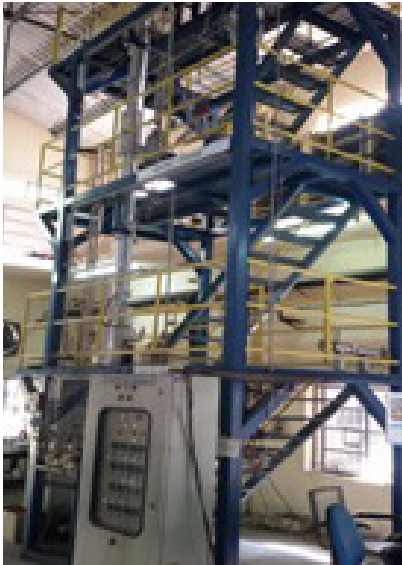
The development of HH process technology has received a couple of prestigious awards:

Golden Peacock Award 2020



FICCI R&D AWARD 2017



LAB/BENCH SCALE UNIT AT CSIR-IICT HYDERABAD	PILOT PLANT AT GACL DAHEJ COMPLEX GUJARAT
	
 HH COMMERCIAL PLANT SIDE VIEW	 HH COMMERCIAL PLANT NIGHT VIEW 
HYDRAZINE HYDRATE COMMERCIAL PLANT CENTRALISED DISTRIBUTED CONTROL SYSTEM CONTROL ROOM	

CSIR Success Story //

Technology Development and Commercialisation of a Novel Sweetening catalyst – ‘Thoxcat ES™’ for LPG and Lighter Petroleum Fractions

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About Technology

The presence of mercaptans in petroleum products like liquefied petroleum gas (LPG), naphtha, gasoline, aviation turbine fuel (ATF), and kerosene is undesirable due to their foul odour and highly corrosive nature. In commercial practice, the lower molecular weight mercaptans present in LPG and light straight run naphtha (LSRN) are extracted with alkali and catalytically oxidised to disulfides with air. This process is termed extractive sweetening. The mercaptans in slightly heavier straight-run naphtha or light thermally cracked naphtha are converted to disulfides by a liquid-liquid sweetening process where both extraction and oxidation occur in the same vessel. In the absence of a sweetening catalyst, excess use of alkali solution makes the two approaches expensive and time-consuming.

In order to achieve import substitution, CSIR-Indian Institute of Petroleum (CSIR-IIP) in collaboration with Bharat Petroleum Corporation Limited (BPCL), has developed Thoxcat ES™, a liquid catalyst in a dilute alkaline solution, for use in processes that involve the oxidation of mercaptans found in LPG/lighter petroleum fractions. This catalyst is intended for use in the petroleum refining industry and has been licensed to M/s LONA Industries, Mumbai since 2007, with a royalty earning of 10% from the sale of the catalyst.

Around 50% of Indian refiners are using Thoxcat ES™ for sweetening LPG. As a way forward IIP-BPCL team has embarked since 2015 on commercialising the sweetening catalyst outside India. It was successfully trialled at Oman Refineries and Petro Chemicals (ORPIC), Oman, in 2016 and at Saudi Aramco in 2020. The product has been approved for regular consumption in its six units in Saudi Arabia.

As a way forward, IIP-BPCL plans to cover at least 10% of the global market in the next five years.

Bulk Production of Thoxcat ES™ at Lona Industries Limited

Lona was established in the year 1962 at Lonavala, Mumbai. It was identified for proven expertise in the production of phthalocyanines. Mr S.R. Dhote is the Chairman and Managing Director of the company,

with a turnover of roughly Rs 250 Crore per annum. The company is engaged in manufacturing metal phthalocyanine-based products exported to the international market, including countries like Canada, UK, Italy, Spain, the USA, Brazil, Turkey, Australia, Japan, Taiwan, Thailand, South Korea, Indonesia, and China.

Keeping in view Lona's potential expertise for producing metal phthalocyanine and its various derivatives, CSIR-IIP and BPCL management entered into an agreement with M/s Lona Industries Limited in September 2007 for regular production and supply of this catalyst, which is a metal phthalocyanine complex. The tripartite agreement was renewed in September 2017.

The production of Thoxcat ES™ at Lona gave employment benefits to around 20 skilled workforces of local origin, which helped in the economic upliftment of their families. We could fulfil the demand of about 25 tons of this catalyst of refinery users since 2007. Yearly production has nearly doubled after ME refineries accepted catalyst for regular use in 2020. The royalty model is 10% to our licensors CSIR-IIP and BPCL on sales realised.

Novelty of Thoxcat ES™

- Thoxcat ES™ demonstrates twice the activity of its competing commercial catalysts.
- The liquid form of Thoxcat ES™ does not gel during extended periods of storage.
- As cobalt phthalocyanine sulphonamide is insoluble in acidic mediums, its isolation is easier during preparation.
- Unlike conventional ones, preparing this catalyst does not require the use of oleum, a highly hazardous and corrosive substance.
- No carryover even in high mercaptide conditions, making it ideal for Middle East (ME) refineries.
- Thoxcat ES™ has a shelf life of 3 years and is cost-competitive.

Quality Control & Hand Holding

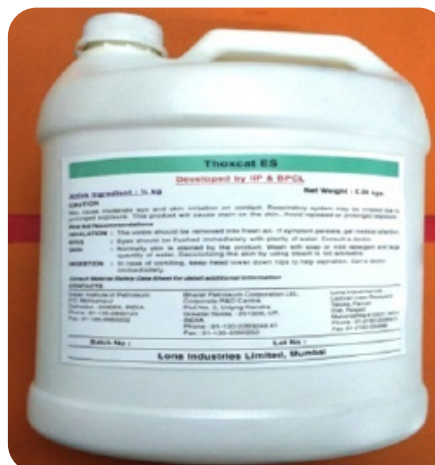
Before supplying to refineries, CSIR-IIP conducts rigorous quality control tests on each batch of produced samples to ensure their clearance. In case of any variation in quality, the BPCL team works closely with CSIR-IIP to identify corrective measures and modifications in the synthesis strategy. They also keep regularly updating on the product's upgrade strategies. Additionally, CSIR-IIP provides hands-on assistance in the form of plant visits during trial productions for new formulations.



Lona Factory



Thoxcat ES™ Product Bottle



Lona Production Facilities

Commercialisation in India

The refinery trial performance proved lower catalyst consumption than another commercial catalyst for similar conversion, validating the catalyst's higher activity. Successful industrial trial runs reflecting its consistent higher activity and lower consumption rates formed its basis for commercialisation. The first successful commercialisation occurred in December 2007 in BPCL Mahul Refinery. Subsequently, the catalyst was commercialised in nine other Indian refineries, namely, HPCL (Mumbai), HPCL (Visag), BORL (Bina), HMEI (Bhatinda), MRPL (Mangalore), IOCL (Digboi & Paradip), RIL (Jamnagar) and BPCL (Kochi). **Today, nearly 50% of the Indian Refinery demand for LPG sweetening catalysts is being met by Thoxcat ES™.**

Commercialisation Challenges in the Middle East & Reformulation for its Solution

During the trial runs at ME refineries, it was observed that the plant configurations were different from those in Indian refineries. One significant issue that arose during the trials was the higher tendency for foaming, which was tentatively attributed to high and fluctuating mercaptide levels in the oxidiser feed. This unique design challenge had not been encountered in Indian refineries before. Additionally, the higher ambient temperatures in the ME region throughout the year were also hypothesised to contribute to this foaming behaviour. In response to this challenge, CSIR-IIP and BPCL R&D conducted a detailed parametric study to reformulate the catalyst and improve its foam control feature, ensuring a competitive edge over alternative sweetening systems. The reformulated catalyst was successfully trialed and accepted for regular use in ME refineries. ***This is the first instance in CSIR-IIP that a CSIR-developed catalyst has been marketed abroad.***

Way Forward

The current catalyst is a co-invention of "CSIR-IIP" and "BPCL," which is in line with the present concept of "Make in India." The invention is protected by nine patents, including two in the USA, two in the UK, two in France, and three in India. The catalyst has been successfully demonstrated and commercialised in ten Indian refineries and two refineries in the ME.

The efforts put into inventing, developing, and commercialising the novel cobalt phthalocyanine sulphonamide catalyst have been recognised by four national awards, including the prestigious CSIR Technology Award for "Innovation" in 2007 and the "Most Significant CSIR-Technology Award" in 2015 for the development and commercialisation of Thoxcat ES™ LPG sweetening catalyst.

Being techno-economically superior, the catalyst has been successfully implemented in 10 out of 23 refineries in India and 2 refineries in the Middle East. Kochi Refineries Limited is presently conducting trials for their Coker LPG units, while Nayara plans to initiate trials soon. It has the potential to replace the existing commercial catalysts the world over. CSIR IIP-BPCL targets commercialising "Thoxcat ES™" in 25 refineries within two years, focusing on ME refineries and in 70 refineries globally over the next five years.

The Accademia Nazionale dei Lincei in Rome

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The Accademia Nazionale dei Lincei is the oldest and most prestigious science academy in Italy. It was founded in 1603 by Federico Cesi – a Roman patrician – with a passion for the natural sciences. The name derives from *lince*, Italian for lynx, for the acute vision attributed to the lynx, which, in that period, was still a common species in Italy. The focus of the Academy under Cesi's vision was to study all the natural sciences from a liberal and experimental viewpoint, free from any traditional encumbrance or authority. One of the first members of the Academy was Galileo Galilei – the great Italian astronomer, physicist and engineer – who joined in 1611.

Today, the Accademia Nazionale dei Lincei has two academy classes, one for the physical, mathematical and natural sciences and the other for the humanities and social sciences. Its current statutes foresee a maximum of about 90 Italian members for each class and an equal number of foreign members and corresponding members who are co-opted annually. Among the past members, one can find several illustrious scholars, from Righi and Pacinotti to Fermi, Pasteur to Röntgen and Einstein, Mommsen to Croce and Gentile, all Olympians of scientific research of their time.

The Accademia Nazionale dei Lincei is an independent institution committed to imparting credible information to its citizens and policymakers about current issues and their plausible solutions. The Academy's members are among the leading scientists and researchers within Italy and abroad.

As per the scopes defined by article 33 of the Italian Constitution, the Academy holds assemblies and meetings of its members; organises national and international congresses, conferences, meetings and seminars; promotes and carries out research activities and missions; confers several prestigious awards and grants; publishes the reports and the proceedings of the congresses, meetings and seminars. It provides – upon request and on its own – opinions to public entities in the fields within its competence.

The Academy also maintains and fosters international cooperation with several foreign national academies and represents Italy in the prime academic international organisations. Among these are the InterAcademy Partnership (IAP), the All European Academies (ALLEA), the European Academies' Science Advisory Council (EASAC), the International Human Rights Network of Academies and Scholarly Societies (IHRN) and others. Over the years, the Academy has served in various executive committees of international organisations. Particularly relevant is the participation in the IAP, a network of over 140 national, regional and global member academies. Founded in 1993, its goal is to provide a collective mechanism for academies to strengthen their crucial roles as providers of evidence-based policy and advice. IAP also helps build the capacity of its new and less-experienced member academies, thus strengthening their ability to take on an advisory role in their nations and to contribute to global discussions.

The Accademia Nazionale dei Lincei is also part of the network of national academies of the G7 and G20 countries; they provide scientific advice for the annual summits of Heads of State and Government. They prepare science-based recommendations related to topics on the summit agendas.

With respect to Science Diplomacy, the Academy is actively involved with various activities. For instance, the *Colloquia on Science Diplomacy* series of the Accademia Nazionale dei Lincei, published by the Institute of the Italian Encyclopedia, was born as a cultural manifesto in support of the objectives of the United Nations 2030 Agenda for Sustainable Development. In the Colloquia, the eminent personalities of world institutions and the presidents of the most prestigious academies discuss current topics of global importance, plausible solutions and future developments of interest for the international community. The themes represent visions of an evolving humanity according to the models of solidarity and sustainable development, international cooperation and multilateralism. An open-access volume of the *Colloquia on Science Diplomacy* is available for consultation at <https://colloquia.treccani.it>.

The Academy combines modernity with tradition and actively participates in discussions on the changing role of science and scientists in society. During the COVID-19 pandemic, the Academy established a committee to express its views and provide input on the many questions regarding SARS-CoV-2. They initiated a webpage containing documents, statements and reports on COVID-19 by the Lincei Committees, Lincei Fellows, and other Academies, Academy networks and institutions.



The Academy also pioneered a significant initiative to increase visibility and to foster interest in topics such as sustainable development, the role of research and education, etc., amongst stakeholders. "I Lincei per una nuova didattica nella scuola: una rete nazionale" ("The Lincei for a new kind of teaching in schools: a national network"), was a project promoted in 2010 by the Accademia Nazionale dei Lincei and by Italy's Ministry of Education, University and Research to organise training activities and refresher courses for teachers, aimed at improving the teaching system. Later, in 2015, this project led to the "I Lincei per la Scuola" ("Lincei for school") Foundation to promote a new kind of teaching in schools.

The project aims to support and encourage the improvement of national education and training systems, giving life to a network of centres, the "**Poli**" which establishes, in the plurality of initiatives, a renewed methodology for teaching scientific subjects capable of stimulating the learning of the scientific method and the development of creativity. The project also aims to facilitate a constructive dialogue at the local level between higher cultural institutions and the School. "I Lincei per la Scuola" is an interdisciplinary project that leads to the formation of a cultured, thinking, curious and informed

citizen and to an inclusive school and engine of justice and social promotion. In the last seven years, the project has involved 23500 teachers and more than one million students.

To summarise, the Accademia Nazionale dei Lincei is an old but lively institution, highly respected within the Italian and the international community, with a reputation that has further magnified after its President for the years 2018-2021, Giorgio Parisi, a theoretical physicist, was awarded the Nobel Prize in Physics (2021). The original motto of the Academy, "the aim of the Academy is not only to acquire knowledge of phenomena and knowledge through a just and at the same time pious life but also to transmit them to men orally and in writing, peacefully, without harm to anyone", formulated four centuries ago has remained essentially unchanged and stronger than ever!

G20 Research and Innovation Initiative Gathering (RIIG) Conference on Materials for Sustainable Energy

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India has taken over the year-long G20 Presidency in December 2022. One of the side events during the G20 Presidency is the Research and Innovation Initiative Gatherings (RIIGs) which is being held at multiple locations in India (viz. Ranchi, Dibrugarh, Diu and Shimla) and is being hosted by various scientific departments (CSIR, DBT, SERB & MoES). Science and Engineering Research Board (SERB) has been identified as the Indian front face of the G20 RIIG. India is hosting five G20 RIIGs during India's G20 Presidency year, including Research and Innovation Ministers' meeting.



Troika (Indonesia, India & Brazil) with DG-CSIR



DG-CSIR addressing the Gathering

The G20 RIIG Inception Meeting was held at Kolkata on 8 February 2023, which was a curtain-raiser event for the RIIG Conferences.

Subsequently, the CSIR-led G20 RIIG Conference on “Materials for Sustainable Energy” took place in Ranchi on 2 March 2023. It encompassed inaugural, technical and valedictory sessions, a plenary lecture on “Strategy towards Low-Carbon Transition driving India towards Net-Zero”, special sessions for interventions, suggestions and presentations by foreign delegates and a panel discussion. The deliberations centred around three priority areas viz, a) 21st Century Challenges Related to Energy Materials & Devices, b) Solar Energy Utilisation and Photovoltaic Technology, and c) Materials and Processes for Green Energy.

Twenty foreign delegates from ten G20 member countries, six invited guest countries and an international organisation joined the RIIG Conference. Additionally, 38 delegates and special invitees from various scientific departments, research and academic institutions and industry from India participated in the event.

Dr Srivari Chandrasekhar, Secretary, Department of Science and Technology (DST), and the Chair of the RIIG events in India, while welcoming the G20 delegates and special invitees, stressed that many G20 nations, including India, have enormous mineral and material wealth which should be sustainably used for meeting our energy requirements. The G20 delegates from Indonesia and Brazil, the other two Troika countries, echoed the importance of the conference in their opening remarks.

Welcoming the participants, Dr Kalaiselvi, Secretary, DSIR and Director General, CSIR, specified that the theme of the G20 under India's Presidency, “*Vasudhaiva Kutumbakam*” or “One Earth, One Family, One Future”, in a way, underscores the need for the entire world to come together and focus on sustainable energy so that we can have one global future with net-zero emissions. She called upon G20 nations to join hands in researching and developing technological solutions for sustainable energy storage, distribution and management.

The conference drew leading experts from esteemed institutions such as IITs, IISERs, and CSIR Labs, industry representatives from companies such as Godi India Pvt. Ltd., and think tanks like NITI Aayog and Indian Energy Storage Alliance. Well-known energy experts and policymakers, including Dr V.K. Saraswat (Member, NITI Aayog), Dr G. Satheesh Reddy (Scientific Adviser to Raksha Mantri), Prof. Ashok Jhunjhunwala (IIT, Madras), Prof. Vijayamohan K. Pillai (IISER, Tirupati), Dr Rahul Walawalkar (President, Indian Energy Storage Alliance), Dr Ashish Lele (Director, CSIR-NCL, Pune), Dr Anjan Ray (Director, CSIR-IIP, Dehradun),



All Participants at G20 RIIG Conference, Ranchi

Mr Saba Kalam (International Solar Alliance) and many others deliberated on the main and sub-themes of the conference.

The panel discussion and inputs from foreign delegates highlighted that sustainable supply chains and renewable resources are essential elements for effective energy transition and achieving net-zero goals of nations while ensuring affordable energy access for all. G20 deliberations on Sustainable Materials for Energy converged towards the understanding that these need to rapidly evolve with due considerations of resources and capabilities available locally while adopting best practices available internationally - including the relatively new areas of storage materials, green hydrogen, CCUS, digital infrastructure, AI/ML, and physical as well as cybersecurity of energy supply systems. It was unanimously agreed that sharing experiences regularly in a structured manner and building capacities for the next generation of sustainable development professionals will help achieve these common goals.

DG-CSIR, Dr N. Kalaiselvi summarised the highlights of the conference. She touched upon the main points presented, which included carbon pricing, alternate materials and green energy, and emphasised the need for open sharing of technologies among G20 countries. She acknowledged that though science is universal, technology may be region specific. Dr Kalaiselvi remarked that a paradigm shift is necessary for how to generate and shift to sustainable energy sources.

News //////////////////////////////////////

High Seas Treaty: Historic Deal to Protect International Waters Finally Reached at UN

In a historic breakthrough, the United Nations member states have finally agreed on a legal framework for regulating activities in the parts of the ocean beyond national boundaries, after nearly two decades of discussions, including five years of negotiations. The newly established High Seas Treaty aims to address the longstanding governance

gaps that have adversely affected the ocean, by providing clear guidelines for the conservation of biodiversity in high seas. In order to safeguard this significant achievement, the High Seas Alliance is urging UN member states to promptly adopt and ratify the treaty under their national laws, so that it can take effect without any delay.

MoUs Signed //////////////////////////////////////

India and US inked an MoU on the Semiconductor Supply Chain

A Memorandum of Understanding (MoU) on establishing a semiconductor supply chain and innovation partnership under the framework of India – US Commercial Dialogue was signed between the two countries following the Commercial Dialogue 2023 held in New Delhi on 10 March 2023. The MoU seeks to establish a collaborative mechanism between the two governments on Semiconductor Supply chain resiliency and diversification in

view of US's CHIPS and Science Act and India's Semiconductor Mission. It aims to leverage complementary strengths of both countries and facilitate commercial opportunities and development of semiconductor innovation ecosystems through discussions on various aspects of the semiconductor value chain. The MoU envisages mutually beneficial R&D, talent and skill development.

India and Mexico signs MoU on Research, Technology and Innovation Collaborations

India and Mexico signed a MoU on research, technology and innovation collaborations with focus on several key technology areas like Aerospace, Electronics Instrumentation & Strategic Sectors; Civil, Infrastructure & Engineering; Ecology, Environment Earth & Ocean Sciences and Water; Mining, Minerals, Metals & Materials; Chemicals (including leather) and Petrochemicals; Energy (Conventional & Non-

Conventional) and Energy Devices; Agri, Nutrition & Biotech and Healthcare on 4 March 2023. With this MoU, both countries aim to contribute effectively to the global society through Research and Innovation Partnerships for technology development, upscaling of each other's Intellectual Property for commercialisation and Research Infrastructure Development & Sharing.

Department of Agriculture and Farmers Welfare and the Development Innovation Lab (DIL) at the University of Chicago sign MoU to Support Agriculture and Farmers

The Department of Agriculture and Farmers Welfare (DA&FW) under the Ministry of Agriculture and Farmers Welfare, Government of India, has entered into a partnership with the Development Innovation Lab (DIL) at the University of Chicago, in New Delhi on 3 February 2023 to explore the opportunities to harness innovation to improve food security, address climate change, and allow farmers to increase their incomes. The partnership will look into innovation opportunities related to agriculture and food security in the context of climate change,

in the present scenario of experiencing a rise in extreme temperatures, floods, and droughts, as well as changes to the monsoon system. Innovations in digital services, weather forecasts, and soil health management could help farmers adapt to these shocks and improve their livelihoods, while improving environmental sustainability of agriculture. DIL will assist DA&FW in its efforts to identify, develop, test, and refine innovations in these and other priority areas, to support India's small holder farmers.

Announcements //////////////////////////////////////

Call for Applications: "Grassroots Science Advice Promotion Awards 2023"

Submission deadline: 30 April 2023

Further information at:

<https://ingsa.org/wp-content/uploads/2023/03/Application-Guide-INGSA-Asia-Grassroots-Science-Advice-Promotion-Awards-2023.docx.pdf>

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Moorthy R, Bibi S (2023) **Water security and cross-border water management in the Kabul river basin.** *Sustainability*, 15(1): 792. <https://doi.org/10.3390/su15010792>

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Call for Proposals //////////////////////////////////////

EU-India/MoES Research & Innovation Cooperation Horizon Europe 2023

Last Date: April 12, 2023

Further information at: https://www.moes.gov.in/sites/default/files/2022-12/Webnotice-CoFunding-MoES-EU-IND-2023-2024-Final-M_1.pdf

DBT-EU Cooperation Programme on R&I 'Horizon Europe' Calls 2023-2024

Last Date: April 13, 2023

Further information at: https://dbtindia.gov.in/sites/default/files/DBT-EU%20joint%20call%20WEBNOTICEWP%202023-24_0.pdf

DST announces co-funding partnership under the EU Framework Programme on R&I 'Horizon Europe' calls 2023-2024

Last Date: April 20, 2023

Further information at: <https://dst.gov.in/sites/default/files/Webnotice%20India%20-%20EU%20Joint%20call%20for%20proposal%20with%20Annex%20A%20B%20C.pdf>

Indo-Argentina Joint Call 2023

Last Date: April 30, 2023

Further information at: <https://dst.gov.in/sites/default/files/Call%20for%20Proposal.pdf>

Forthcoming Events //////////////////////////////////////

Science Diplomacy Roadshow - San Francisco

Date: May 18, 2023

Further information at:

https://www.scipolnetwork.org/event-details?recordId=recBR46EXFNuYtngr&utm_source=social2303&utm_medium=social-media&utm_campaign=twitter