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Science Reporter

A CSIR Publication

CSIR-INDIA
सीएसआईआर
CSIR
भारत का नवाचार इंजन
The Innovation Engine of India

Special Tributes By

- Dr K Kasturirangan
- Dr Raghunath Mashelkar
- Dr T Ramasami
- Dr Shailesh Nayak
- Dr Anil Gupta
- Dr RV Bhavani

Remembering the Legacy of Prof. MS Swaminathan

A Visionary & Inspiring Leader

Features

- Century of BITM
- 3D Printing
- Cooking Metals the Mysore Pak Way!
- Quiz, Fiction, Puzzles & much more

Science Reporter

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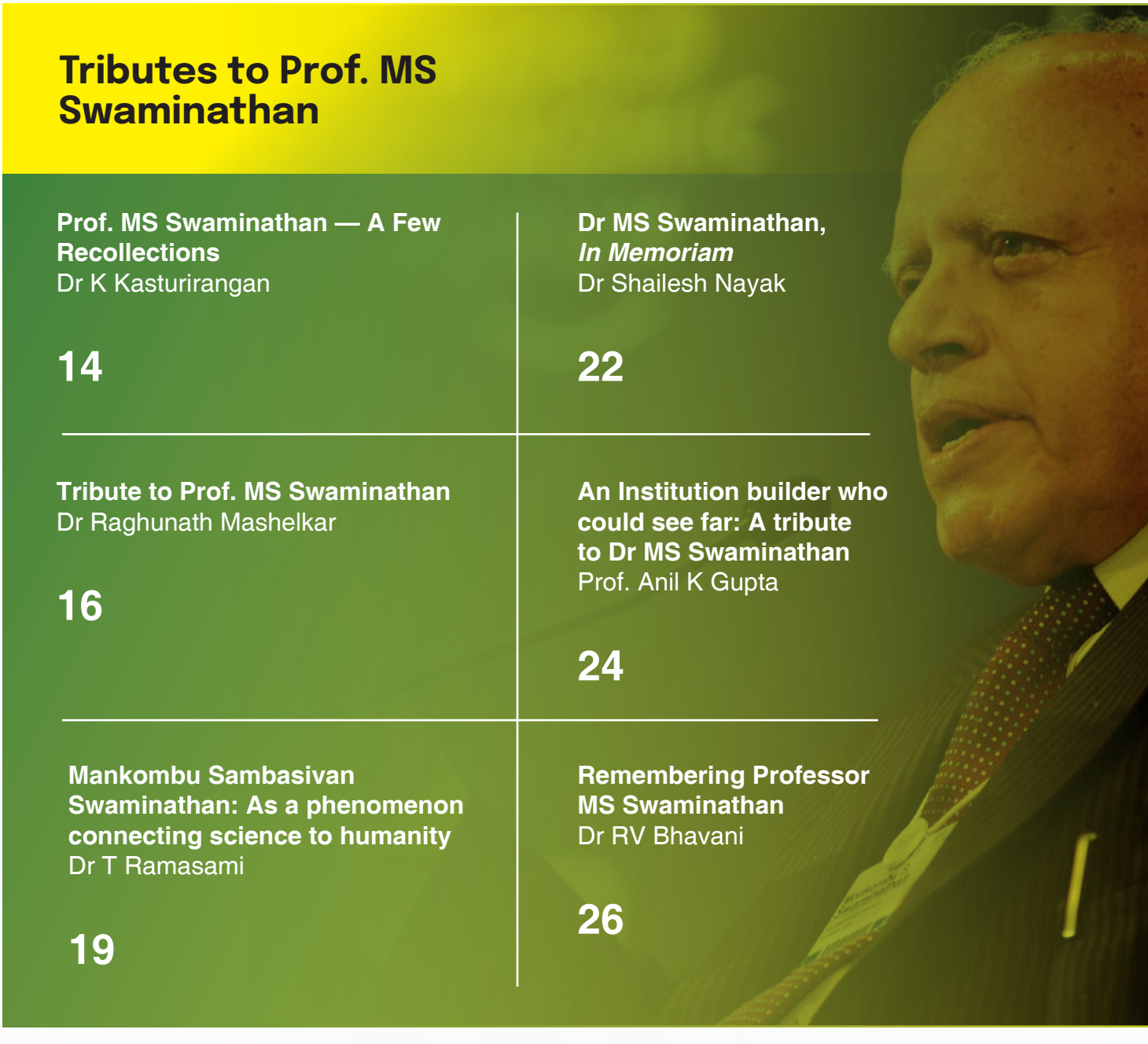

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EDITORIAL

Prof. MS Swaminathan is no more — Passing of an era

IN the sad demise of Prof. MS Swaminathan on 28 September 2023, India lost a visionary, an inspiring leader, and a champion of farmers. A true nationalist, Prof. Swaminathan chose to return to India despite being offered a faculty position at the University of Wisconsin. And back home, it was because of his commitment and efforts that India could transform itself from being drought-stricken and dependent on US imports in the 1960s to becoming self-sufficient in food production in the 1970s.

Science Reporter remembers with pride its association with Prof. MS Swaminathan on more than one occasion. For instance, on the occasion of the National Technology Day, the May 2018 issue of *Science Reporter* focused on "Science & Technology in India". We were immensely grateful that on our request, Prof. Swaminathan sent us an article "Shaping Our Agriculture Future", where among other ideas, he called for setting up "climate risk management R&D centres at least one at every block level, to be supported by trained Climate Risk Managers, one woman and one man from each Panchayat".

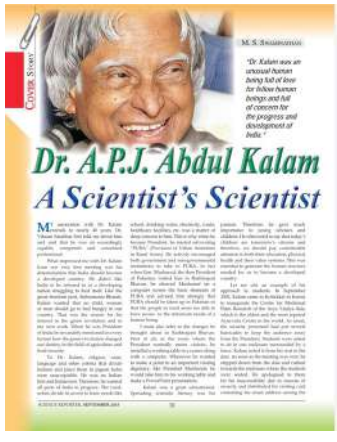

SCIENCE IN INDIA | SPECIAL

Shaping Our Agriculture Future

M.S. Swaminathan

In an interview published in the March 2016 issue of *Science Reporter*, on being asked for a message for the younger generation, he said "You may not be a scientist but you can get away from superstitions and get away from all the wrong things that are happening in our society. Make friendship with science."

And in the September 2015 issue, on the sudden demise of Dr APJ Abdul Kalam, apart from stalwarts like Prof. CNR Rao, Dr K Kasturirangan and Dr RA Mashelkar, Prof. Swaminathan also agreed to pay his tributes. Calling Dr Kalam a "Scientist's Scientist", he wrote: "To Dr Kalam, religion, caste, language and other criteria that divide Indians and place them in pigeon holes were unacceptable. He was an Indian first and Indian last. Therefore, he wanted all parts of India to progress."



This issue of *Science Reporter* is dedicated to Prof. MS Swaminathan, in whose death we have lost a great nationalist, agriculturist and a world thought leader. This issue of *Science Reporter* pays Prof. Swaminathan rich tributes contributed by the likes of Dr K Kasturirangan, Dr RA Mashelkar, Dr T Ramasami, Dr Shailesh Nayak, Dr Anil Gupta and Dr R Bhavani (who worked with him closely).

Hasan Jawaid Khan

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Moon Race for Helium-3!

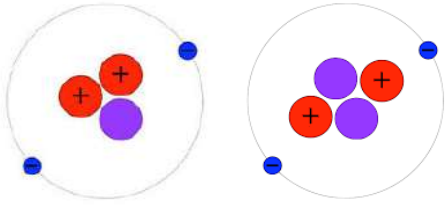
INDIA launched Chandrayaan-3 on 14 July 2023 and its lander along with the rover made a soft landing near the lunar South Pole on 23 August 2023. The Pragyan rover of Chandrayaan-3 has discovered the presence of aluminium, sulphur, calcium, iron, chromium, titanium, manganese, silicon and oxygen on the Moon.

The USA has already started its Artemis mission for lunar exploration. It has planned to send four astronauts including a woman to the lunar surface in 2025. China has planned to send its astronauts to the Moon in 2030. Japan, South Korea, the United Arab Emirates and the USA have planned lunar missions in 2023. Eleven countries have succeeded in sending spacecraft to the Moon. After the 70s, the USA and Russia had stopped lunar missions. But suddenly they along with China and some other countries have become very serious about lunar explorations.

Dominated by the growing competition between the USA and China, the return to the Moon is now motivated by a desire to study and possibly exploit resources that can be found there. Of these, Helium-3, a very rare material on Earth, represents the most significant potential in the field of energy.

Helium-3 is an isotope of Helium. The normal helium atom Helium-4 has two protons and two neutrons in its nucleus. But Helium-3 has two protons and one neutron in its nucleus. Although it is very rare on Earth, there is plenty of this material on the Moon. The existence of Helium-3 was first proposed in 1934 by the Australian physicist Mark Oliphant while he was working at the Cavendish Laboratory of the University of Cambridge. The American scientists Luis Alvarez and Robert Cornog first isolated it in 1939.

It is believed that when a celestial body named Theia collided with the early Earth, some mass of the Earth



was separated to form the Moon. Then why is Helium-3 available on the Moon and not on Earth? Sun produces vast quantities of Helium through a thermonuclear fusion process. In this process hydrogen atoms are combined to form Helium and the Sun gets a lot of energy from this. A small amount of Helium-3 is also produced in this reaction. Both types of Helium travel toward the Earth as part of the solar wind. But the Earth's magnetic field pushes them away and so Helium-3 does not reach Earth.

The solar wind containing Helium-3 also travels to the Moon. But the Moon has a negligible amount of magnetic field so Helium-3 easily lands on the lunar surface. For billions of years, the action of the solar wind has caused the accumulation of Helium-3 on the Moon. It accumulates in lunar dust and rock. It has been estimated that about 1.1 million metric tons of Helium-3 have been deposited in lunar soil. In comparison, Earth is estimated to have only 300 kg of Helium-3. Even this small amount has not come from solar wind. It is the by-product of the maintenance of nuclear weapons. Every year about 15 kg of Helium-3 comes out from this maintenance.

Helium-3 can provide safer nuclear energy through nuclear fusion process. It is not radioactive and does not produce any dangerous by-products. This isotope is also useful for other applications including cryogenics, quantum computers and MRI machines. Moon seems to be its main reservoir.

At present, we are producing atomic power from Uranium-235 (U-235) by nuclear fission process. However, U-235 is a radioactive substance and in case of any accidents

Meat Masala Plant

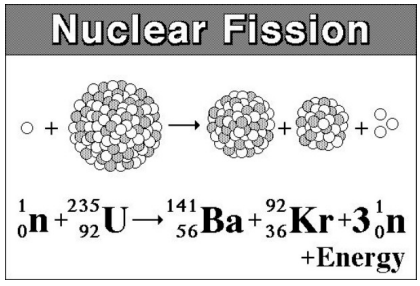

A branch of meat masala plant (Jamaica pepper; *Pimenta dioica*) with leaves and fruits

"Meat Masala" — a common Indian blend spices that effortlessly transforms meat, fish, and egg curries into delectable delights. It is basically a blend of eighteen different types of spices, namely, powder of mustard seed (*Brassica nigra)*, turmeric (*Curcuma longa)*, coriander seed (*Coriandrum sativum)*, fennel seed (*Foeniculum vulgare*), cumin seeds (*Cuminum cyminum*), pepper seed (*Capsicum annuum*), inner bark of cinnamon (*Cinnamomum verum*), etc.

Another plant whose dried and ground leaves and fruits hold the power to elevate meat, fish, and egg curry recipes to new heights of deliciousness is *Pimenta dioica*. Also known as allspice plant/Jamaica pepper or myrtle pepper, the dried ground leaves and seeds of this plant could replace the conventional meat masala, infusing dishes with a symphony of mouth-watering flavours. The dried leaves of this plant give the flavour of five different types of spices, i.e. fragrance of Nutmeg seeds (*Myristica fragrans*), mace Spice (crimson red coloured fruit of *Myristica fragrans*), cloves, (reddish brown coloured flower buds of *Syzygium aromaticum*,), black pepper (black coloured fruits from *Piper nigrum)* and cinnamon.

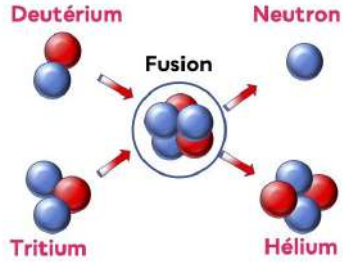
This plant is a mid-canopy tree native to the Greater Antilles, southern Mexico, and Central America (island of Jamaica). It is cultivated in many warm parts of the world. The name allspice was coined as early as 1621 by the British, who appreciated it as a spice that combines the flavours of cinnamon, nutmeg, clove, etc.

the radiation may harm many people. Further, the management of radioactive nuclear waste is a problem.



Nuclear Fission Reaction

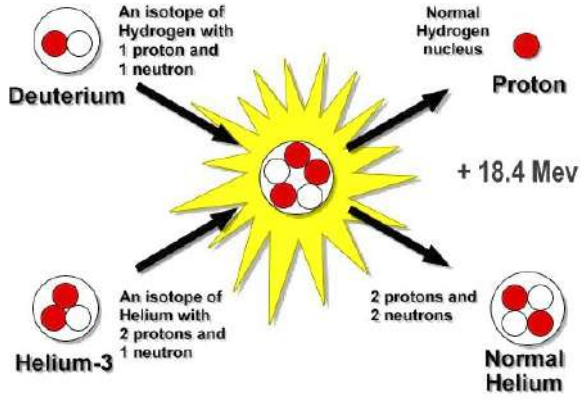
In a nuclear fusion reaction, two smaller atoms are combined to form a larger atom and in this process, a lot of energy is released. The process requires high-temperature (over 100 million degrees Celsius).



Nuclear fusion reactor

In the fusion reaction with deuterium and tritium, along with energy helium, a fast neutron is released. This fast neutron causes significant energy loss and is extremely difficult to contain an automatic runaway process. If Helium-3 is used in the fusion reactor, it will create a normal helium atom and a proton, which wastes less energy and is easier to contain. Hence, Helium-3 can provide efficient nuclear power with no waste and no radiation problems.

Extraction of Helium-3 for practical use is a difficult proposition. The amount of Helium-3 is 50 parts per billion in lunar soil and hence it requires a lot of refining. It is estimated that about one million tons of soil will have to be mined for the production of 70 tons of Helium-3. To carry so much soil to the Earth will be a huge task. Even if we refine it on the Moon and carry only the Helium-3, still it may pose many problems.

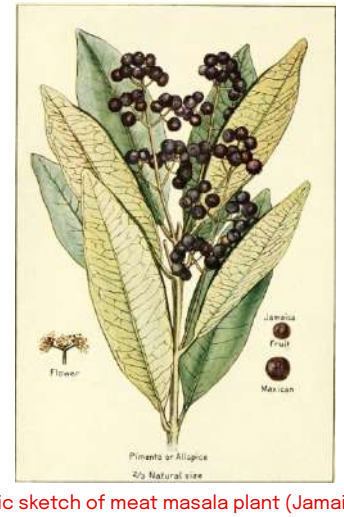


Nuclear fusion reactor using Helium-3

One alternative suggestion is to establish a nuclear plant on the lunar surface and then transmit the produced energy by converting it to microwaves. Although it seems like fiction now, it may not be impossible in future considering the rate at which science and technology are progressing.

Russia and China have already announced their intentions for mining the Moon. China's Chang'e-4 (2018) and Chang'e-5 (2020) missions have made significant progress in the study of the topography and composition of lunar soil. One of the objectives of these trips is to determine the exact amount of Helium-3 present. The Beijing Research Institute of Uranium Geology is even measuring the content of Helium-3 in the lunar soil, evaluating its extraction parameters, and studying the ground fixation of this isotope.

Contributed by Mayadhar Swain, Editor, *Science Horizon*. Address: Plot No. 70, Laxmi Vihar Phase-1, Bhubaneswar-751018. Email: mayadhar2002@yahoo.co.in



Artistic sketch of meat masala plant (Jamaica pepper, *Pimenta dioica*) with its different parts

In India, these plants are cultivated in Maharashtra, Tamil Nadu, Karnataka and Kerala. These plants are also found in the Western Ghat mountain regions. It has also been reported to be cultivated in West Bengal (the northern part of Bengal).

The berry fruits are collected when green and unripe and are usually dried in the sun (nearly about 6.5 to 9.5 mm in diameter). When dry, they become brown/black in colour. Factors such as the region of cultivation, the maturity stage of berries during harvest, storage conditions, etc. impact the quality of pimento. Third year onwards, it enters into the reproductive phase i.e., it starts developing fruits. Since then, every year, flowers start blossoming in the month of May and fruits are obtained till the month of August. Fresh leaves are similar in texture to bay leaves and are similarly used in cooking.

In addition to its applications in cuisine, scientists have isolated a crucial active component "Eugenol", an active antioxidant molecule. It thus holds the potential for drug development, as it also has anti-bacterial, anti-fungal, anti-inflammatory, and anti-cancer properties.

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"Cooperative Federalism" in India

MONITORING and Evaluation systems (M&E) for accountability play a crucial role in good governance systems. However, implementation structures and governance systems vary at the national, state, district and local levels. Efforts to strengthen M&E systems and capacities need to address these complexities, diversities, and inequities across the country. Hence, cooperative federalism becomes the cornerstone for achieving synergies and cross-learnings across levels of government, from the Union Government to multiple State Governments.

Development Monitoring and Evaluation Office (DMEO), NITI Aayog, has been partnering and working with States towards building a strong M&E ecosystem across India. The National Conference on Monitoring, Evaluation and Learning (NCMEL) is one such initiative towards this goal, which provides a platform for sustained conversation in the domain of M&E, allowing more synergy and coherence in the collaborations among various stakeholders.

DMEO organised the second National Conference on Monitoring, Evaluation and Learning with the objective of building institutional capacities and empowering critical governance systems at the Centre and State levels. The event discussed the emerging issues and challenges at the national and sub-national levels. The central theme of the conference was "Monitoring & Evaluation for Sustainable Development through Cooperative Federalism" including six sub-themes.

There were nine sessions of NCMEL across two days. The first technical session appraised the participants about M&E for maximising public expenditure efficiency and fostering cooperative federalism. The panellists provided ideas on various essential domains pertaining to M&E and focus was laid on bringing M&E to the ambit of field practitioners as well as beneficiaries who have high stakes in the schemes. Capacity building of government functionaries to increase the quality of evidence is necessary at all levels of government. There are emerging best practices for enhancing the public expenditure efficiency at the sub-national level through evidence. The inaugural session also saw the launch of *M&E @70: Strengthening India's Evidence Systems for Accelerated Reforms and Inclusive Growth* — A Compendium of Essays.

The second session was based on the localisation of outcome-monitoring. The panel discussed how the localisation of outcome monitoring at various levels of governance will enable the achievement of national development goals. It was realised that outcome-monitoring at the local level especially when linked to the budgetary and planning process can help us efficiently allocate resources, prioritise and assign ownership to various levels of government. Monitoring of the Smart Cities mission has helped determine which projects have improved livability, economic ability and sustainability.

The third session was on creating robust data systems and processes to enable data use for decentralised decision-making. It highlighted that data collection should be less cumbersome and should be generated when the action happens and this transactional data should be available on a real-time basis across all levels of decision-making. Empowering district and state administrations in developing local datasets and building their capacities will enable the use of data for decentralised decision-making.

The fourth session discussed the role of data, technology and innovation in more inclusive M&E practices. The session focused on how the advent of the data age and how the significant advancements in technology can be leveraged going forward to enhance M&E practices. There is a need to focus on the purpose of M&E rather than the technology because even the simplest technology can do the trick.

The fifth session was on taking a participatory and citizen-centric approach to M&E. The key takeaway was making citizens aware of their rights and giving access to make their voices heard to enable the government to receive feedback from all. Community is a force for positive change and they are capable of technology use, stakeholder engagement and advocacy for change. Partnership with citizens in the process of development should be based on the 3 R's — Respect, Recognition, and Reward.

The sixth session on Strengthening Evaluation Capacities in States provided an overview of the evolution of evaluation at the state level, the current status of the ecosystem and best practices of states and also the opportunities for collaboration across the States, Centre and development partners for developing evaluation capacities at state.

Designing Inclusive Evaluations to be responsive to outcomes for children, adolescents and women was the seventh session of NCMEL. Evaluations should define the outcomes that matter for the most marginalised by using the participatory approach and also looking at unintended consequences.

The eighth session specified evidence need for sustainable food systems and livelihoods. This session discussed these challenges and the role of M&E evidence in building sustainable food systems and resilient livelihoods. The last session was on pathways for institutionalising evaluation at the National level. It provided recommendations to address sectoral evidence needs, outcome budgeting processes and support outcome achievement for strengthening state evaluations.

Acknowledgement
Authors thank Dr Sekhar Bonu, Ex-Director General DMEO, NITI Aayog, and the core team of NCMEL namely Shri Shailendra Dwivedi, Dr Shweta Sharma, Ms Disha Bhattacharjee, Ms Urvashi Prasad, Mr Ashish Desai, Mr Paramjyoti Chattopadhyay and Mr Abinash Dash.

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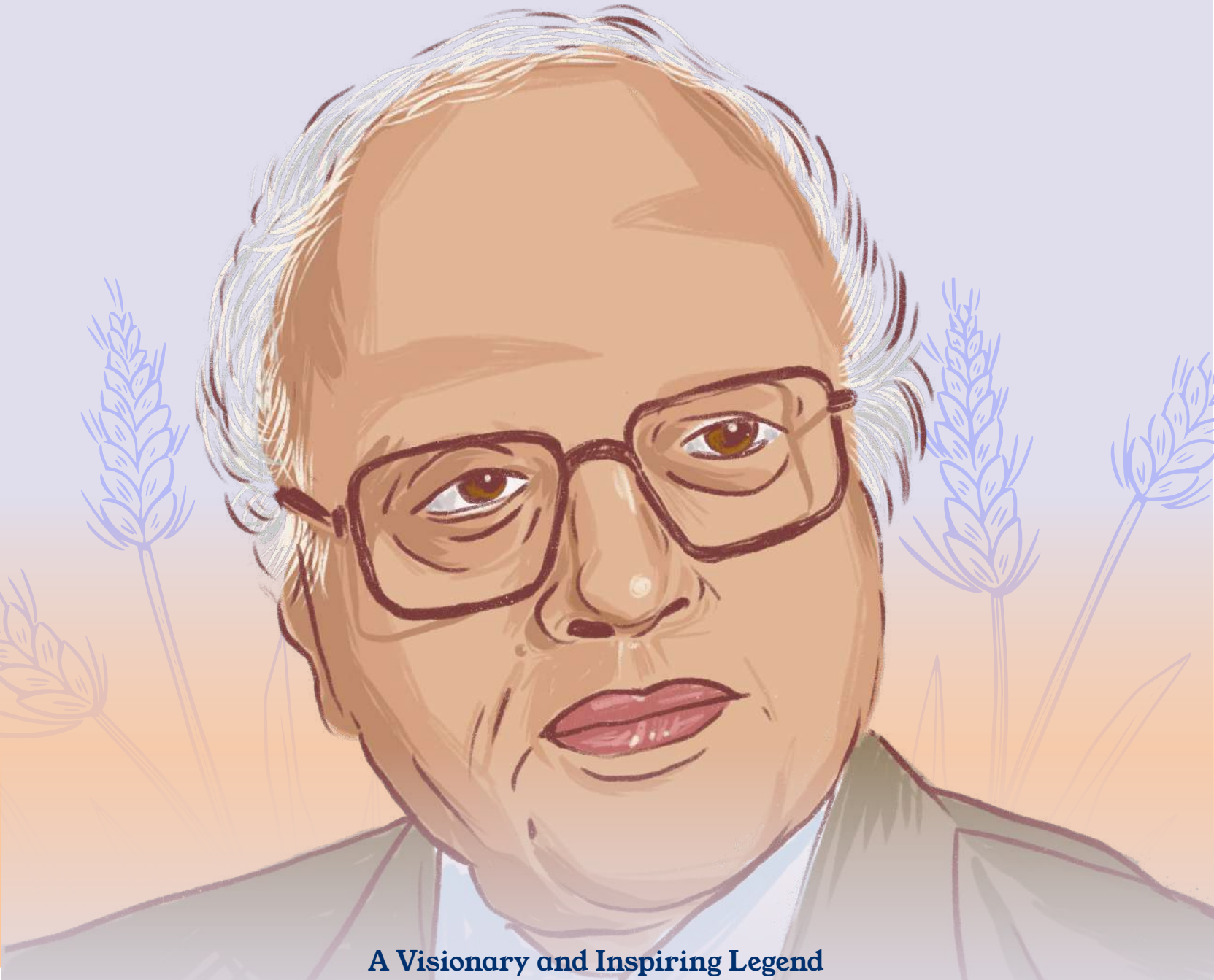
Science Reporter pays tributes to Prof. MS Swaminathan



A Visionary and Inspiring Legend

Born: 7 August 1925, Kumbakonam
Died: 28 September 2023, Chennai

Prof. Monkombu Sambasivan Swaminathan was widely recognised as a visionary leader who led India's Green Revolution that raised the country's agricultural output, transforming India from a grain-importing nation to an agriculturally self-sufficient country. His significant contributions as an agricultural scientist left a lasting impression on Indian agriculture. His unwavering dedication has motivated and influenced generations of professionals. The nation is grateful for his enduring legacy.

Prof. MS Swaminathan
A Few Recollections

Dr K Kasturirangan
Former Member, Rajya Sabha
Former Chairman, ISRO
Former Member, Planning Commission
Former Director, National Institute of Advanced Studies, Bengaluru

I am indeed very privileged to be asked to give my own impressions about Prof MS Swaminathan, a towering personality who strode like a colossus India's scientific firmament for more than several decades in the recent past. The country and the world know him as the Father of India's Green Revolution, about which I need not have to elaborate.

I recall in this connection my earliest remembrances, when Dr Vikram Sarabhai wanted to promote remote sensing for earth resources applications in India, as a part of his innovative vision to explore the use of space for national development. Thought leaders like Dr Vikram Sarabhai, Dr PR Pisharoty and Prof. MS Swaminathan, pioneering the idea of remote sensing for generating timely and precise information regarding natural resources, found that the policy makers and science administrators were sceptical about the utility of this technology in India. As an initial step towards convincing the potentiality of remote sensing, Dr Sarabhai decided to meet the then Prime Minister, Madam Indira Gandhi. The meeting was fixed outside office hours and in her residence. Carefully prepared colour slides on remote sensing were made to ensure that the presentation made the right impact on the Prime Minister. Besides, Dr Sarabhai, Prof. Ramanathan and Dr Pisharoty of Physical Research Laboratory, the meeting was also attended by Prof. MS Swaminathan. According to Dr Sarabhai, the Prime Minister just heard them and said nothing. When enquired what it meant, Dr Sarabhai remarked, "That does not matter, Prime Minister did not object and that means she approves."

Prof. Swaminathan who was one of the key participants of this pioneering discussion also made a practical suggestion to use remote sensing to study coconut wilt disease in Kerala. Thus, the first step in the use of remote sensing with cameras at high altitude to look at the ground features related to earth resources in India was born. Earth Observation activities using multispectral information started with the pioneering experiment by Prof. Pisharoty and his associates, as suggested by Prof. Swaminathan, on the detection of coconut root-wilt disease, which was carried out in 1970, using colour-infrared aerial photography obtained from a helicopter. Since then, Prof. Swaminathan's involvement in ISRO's conceptualisation and planning of several applications of remote sensing, in particular to those related to agriculture, water and environment became a regular practice.

I still recall when India's first ambitious operational remote sensing satellite, IRS, was to be designed and the camera systems to have the right optimisation of performance parameters such as spatial, spectral, temporal and radiometric resolutions were to be chosen, the importance of agriculture and vegetative cover studies became one of the key aspects to be addressed. It is here again that ISRO used Prof. Swaminathan's vast knowledge in this area and with respect to the Indian condition. India's successful programme

"Earth Observation activities using multispectral information started with the pioneering experiment by Prof. Pisharoty and his associates, as suggested by Prof. Swaminathan, on the detection of coconut root-wilt disease, which was carried out in 1970, using colour-infrared aerial photography obtained from a helicopter."

"He was a great champion of farmers' rights and the MS Swaminathan formula for agriculture pricing is still invoked when policy decisions are to be made on related matters."

on remote sensing, particularly using it for agriculture and related aspects like water and soil characterisation, has been decisively influenced by the wisdom that Prof. Swaminathan brought to bear for the benefit of ISRO.

During my tenure as Chairman, ISRO, I had several occasions to meet Prof. Swaminathan, to discuss advanced concepts in remote sensing that could improve the accuracy and timeliness of the agricultural resource inventory. This led to finally establishing an operational capability to provide timely and right information to the Bureau of Economics and Statistics of the Ministry of Agriculture on the one side, and culminating in the setting up of the Mahalanobis National Crop Forecast Centre on the other.

I had the privilege of overlapping my tenure as Member, Rajya Sabha with Prof. Swaminathan. I vividly recall the interventions that Prof. Swaminathan made on important discussions on matters of agriculture and environment. His statements were often heard with rapt attention by our fellow Members. He was a great champion of farmers' rights and the MS Swaminathan formula for agriculture pricing is still invoked when policy decisions are to be made on related matters.

During my tenure as Member of the erstwhile Planning Commission, I was assigned specific responsibilities related to agricultural research among other roles. I had the opportunity to interact with Prof. Swaminathan on several matters that came up during this period. In particular, I recall the very incisive inputs that we in the Planning Commission received from him, on the strategies that we need to adopt in coping with climate change. They were very farsighted and scientifically rigorous in their rationale.

Lastly, when I took over as Director of the National Institute of Advanced Studies (NIAS), Bengaluru, Prof. Swaminathan was the Chairman of their Governing Board. His guidance to the functioning of the institute, particularly in the context of its multidisciplinary character was truly visionary. Further, during his tenure, we restructured NIAS according to disciplines of research, introduced a PhD programme cutting across Science, Humanities and Social Sciences, rationalised the salary structure for the faculty and added a new faculty block.

To me, personally, it was a great honour to have known him and to have worked with him in several contexts over a number of years. I should say that he had a very special regard for me, which got displayed whenever he invited me to the MS Swaminathan Research Foundation (MSSRF) in Chennai, either to deliver an important lecture, or as an invited speaker at international meets and even to some of the personal milestones regarding his own life and career.

To me, these were all the highpoints of our special relationship, and at this moment when he is no more, I feel consoled by the fact that he imbibed into me a part of his legacy, however, modest it may be, in contrast to what he has bequeathed to his world.

Tribute to Prof. MS Swaminathan

Image Credit: worldfoodprize.org

Dr Raghunath Mashelkar, FRS
National Research Professor
Former Director General, CSIR
Former President, Indian National Science Academy

IN the annals of history, there are individuals, whose contributions transcend their lifetimes, leaving an indelible mark on the world. Professor MS Swaminathan, popularly referred to as the "Father of the Green Revolution," is one such luminary, whose legacy continues to shape the destiny of nations. Prof. Swaminathan›s life and work have been an ode to the betterment of humanity through agriculture.

Prof. Swaminathan's pioneering work in Green Revolution has to be viewed in a context. Our post-independent India lived a 'ship to mouth' existence and India's image was that of a 'begging bowl'. It was in those circumstances of scarcity of both food and of our national dignity that Prof. Swaminathan achieved the near impossible of making the nation move from 'food scarcity' to 'food surplus' and from national 'despair' to national 'dignity'.

Prof. Swaminathan saw farther than all of us mortals. For instance, he had cautioned about ecological concerns relating to the practice of intensive agriculture as early as January 1968 in his address to the Indian Science Congress.

And he kept on repeating his message. In 1999, in his book 'Century of Hope: Towards an Era of Harmony with Nature and Freedom from Hunger' he had said, "What nations with small farms and resource-poor farmers need is the enhancement of productivity in perpetuity without associated ecological or social harm. The Green Revolution should become an evergreen revolution rooted in the principles of ecology, economics and gender and social equity."

Prof. Swaminathan's 'Evergreen Revolution' is based on a 'Systems Approach' with concurrent attention to each and every component of ecological foundation. He strongly believed that 'Evergreen Revolution' which is most suitable for hundreds of millions of resource-poor small and medium farmers, necessarily had social and gender dimensions.

In 1987, he was honoured with the first World Food Prize. He used the proceeds to give a gift to the nation in the form of the MS Swaminathan Research Foundation (MSSRF), in the year 1988.

The Foundation has done pioneering work to accelerate the use of modern science and technology for sustainable agricultural and rural development with emphasis on tribal and rural communities with a pro-poor, pro-women and pro-nature approach. On a number of occasions, Prof. Swaminathan invited me to speak at the events in the Foundation. While addressing him in my speeches, I alwayss used to begin by calling him as a Statesman of Science, because that is what I believe he was.

"In 1987, MS Swaminathan was honoured with the first World Food Prize. He used the proceeds to give a gift to the nation in the form of the MS Swaminathan Research Foundation (MSSRF), in the year 1988."

"Prof. Swaminathan was a social reformer, advocating for the welfare of the farming community, especially women and marginalised groups. He believed that gender equity in agriculture was not just a matter of justice but also a path to greater productivity and prosperity."

I have many fond memories of my personal interactions with him. When I was the Director General of CSIR, he was the Chairman of the Research Council of CFTRI. He was, in fact, a great guide, friend and philosopher to CSIR. Our CSIR family will remain ever so grateful to him.

On a personal level, I remember him as a very pleasant, humble, soft spoken, dignified but a quite unassuming person. He had a demeanour, which concealed his brilliant intellect and amazing achievements with countless global accolades. He was a great listener too. He made ordinary people look extraordinary. So big was his heart.

I will just highlight two events. The first event has to do with my own realisation that Prof. Swaminathan was a social reformer, advocating for the welfare of the farming community, especially women and marginalised groups. He believed that gender equity in agriculture was not just a matter of justice but also a path to greater productivity and prosperity. His efforts to uplift rural communities through education, healthcare, and social empowerment left an indelible mark on the landscape of rural India. And I was lucky to have a personal experience of his vision of what he called 'Village Knowledge Centres'.

I remember Prof. Bruce Alberts, who was then the President of the US National Academy of Science, had visited India in 1998. I distinctly remember Professor Swaminathan organising our special visit to Pondicherry, where Professor Alberts and I were shown the 'ahead of time' experiments that he was doing to build what he referred to as the 'Village Knowledge Centres'. These were truly novel models being tested by the MS Swaminathan Research Foundation on creating new knowledge systems in the villages around Pondicherry. The knowledge system for sustainable food security in the Pondicherry villages had its goal as the empowerment of rural women, men and children with information relating to ecological agriculture, economic access and utilisation. Such knowledge systems were being managed by local youth at the Village Knowledge Centre, from where the computer-aided information system was operated. Farmers were becoming the knowledge workers, and they were also being trained to maintain a "Soil Health Card" to monitor the impact of farming systems on the physical, chemical and microbiological components of soil fertility.

Our Hon'ble Prime Minister, while paying tribute to late Prof. Swaminathan on 7 October this year, has made a special

mention of his experience during the time he was Chief Minister of Gujarat. Here is what he has said:

"Among the many initiatives we launched was the soil health card, which enabled us to understand the soil better and address problems if they arose. It was in the context of this scheme that I first met Swaminathan. He appreciated the scheme and also shared his valuable inputs for the same. His endorsement was enough to convince those who were sceptical about the scheme that would eventually set the stage for Gujarat's agricultural success."

There is another remarkable event that left a mark on my mind. I had the privilege of giving the Ranganathan Memorial Oration in Chennai. Shri C Subramaniam was the chief guest, and Professor Swaminathan was the guest of honour. That was an incredible combination, since both of them were responsible for the phenomenal green revolution in India.

In my speech, I talked about the green revolution, white revolution and then I said that there was a grey revolution in India. I was referring to the grey matter in the brain. I said that 6% of the Indian population with an average age of 26 is generating one-third of Indian exports. I was, of course, referring to IT and IT related services.

When it was the turn of Professor Swaminathan to make the final remarks, he gently but firmly said, "Dr Mashelkar is talking about grey revolution. It has to do with the high-quality brain of our young population. Does he know what is happening to the development of the brain today of young infants born in poor families? Dr Mashelkar should know about how due to the malnutrition of the poor women, the children that are being born to them are suffering from a lack of brain development. Therefore, nutritional revolution is the need of the hour."

And of course, the remarks of this great visionary were so right. The nutritional revolution is deeply intertwined with our very future. But to achieve a nutritional revolution, it is important to provide the young children with the right food, rich in nutrients at an early stage. It goes beyond mere calorie intake and emphasises the importance of a balanced diet that includes all essential nutrients. To put it simply, it's not just about having enough food; it's about having the right kind of food.

There are multiple dimensions to nutritional revolution. But I would like to bring forth a specific one.

In 2021, a young innovator Senthil Murugesan won the Anjani Mashelkar Inclusive Innovation Award set up by The Anjani Mashelkar Foundation, which I had started in the memory of my late mother.

"Prof. Swaminathan was not an individual, he was an Institution. Individuals go but Institutions remain for ever."

This inclusive innovator Senthil had used a high technology to create an affordable innovation called SaveMom, which is a holistic hardware-cum-software solution for maternal and childcare that safeguards the journey of a pregnant woman and the new-born child. The price that one has to pay for this service is just Rs 1000 for 1000 days of use! That is a rupee per day!

SaveMom involves point-of-care devices and wearables for continuous tracking of vitals of the pregnant mother and a backend software, which is accessed by doctors in real time. The software also has AI-based decision support system for doctors which can predict pregnancy risks in the first trimester as against the third trimester in conventional processes. On the basis of the risk profiles, the software recommends the right nutrition to the mothers and children and ensures channelising this nutrition through the existing support system.

The SaveMom solution is becoming an active driver in the 'nutrition revolution' across over ~7000 villages in India so far and is helping grow healthier babies and mothers across the country.

I am quite sure that Prof Swaminathan would have been very happy to see this humble technology-led contribution to his dream of nutritional revolution that he had emphasised decades ago during my Ranganathan memorial oration.

As we pay homage to Prof. MS Swaminathan, we must recognise that his legacy is not confined to the pages of history but continues to shape the future of agriculture and food security. His enduring commitment to sustainable, equitable, and environmentally responsible farming practices is even more relevant today than ever before in a world grappling with climate change and food insecurity.

Prof. Swaminathan›s life and work stand as a testament to the transformative power of science, compassion, and dedication. He is not only the Father of the Green Revolution but also an inspiration for generations of scientists, farmers, and policymakers worldwide. In celebrating his contributions to agriculture and the nation, we honour a legend whose spirit continues to guide us towards a brighter, more sustainable future.

Prof. Swaminathan was not an individual, he was an Institution. Individuals go but Institutions remain for ever.

Therefore, here is to wish that this great Ratna of Bharat will be honoured with our nation's highest civilian honour, Bharat Ratna, because although Prof. Swaminathan is no more, he will be there for us, everywhere. He will remain an inspirator, rather a timeless inspirator.

Mankombu Sambasivan Swaminathan
As a phenomenon connecting science to humanity

Dr T Ramasami
Former Secretary, Department of Science & Technology, Ministry of Science & Technology
Former Director, CSIR-CLRI

"The professional life of Dr MS Swaminathan is akin to the elephant seen by blind men in parts. The totality of the persona of Dr MS Swaminathan's contributions to society is far too large for most to comprehend."

ON 7 August 1925 was born a star on the Earth. On 28 September 2023, the star departed leaving behind rich lessons and legacy for generations to come. Between the two dates, Dr MS Swaminathan, the star, enriched the country and the earth through his stellar work contributions.

All of us were taught of an ethical parable of five blind men trying to see an elephant through their sensation and experience. The professional life of Dr MS Swaminathan is akin to the elephant seen by blind men in parts. The totality of the persona of Dr MS Swaminathan's contributions to society is far too large for most to comprehend. Various pillars of his phenomenal contributions are captured by many in parts.

The context of Indian food insecurity prevailing in the mid-sixties in India defines the value of the effort and impact of Professor MS Swaminathan. The country was struggling to feed a third of the current population in the mid-sixties. Trusting in science and technology and investing into technology-led solutions to the societal problems needed a bold leadership and actions backed by conviction. Indeed, technology-led agricultural solutions were found and implemented on the field with the help of a large number of farmers. That India became self-sufficient in food supply within as short a span of five years of time is no mean achievement.

India's Green Revolution is seen as a lesson for the humanity of the developing world. In 2023, India is not only able to produce crops for meeting the needs of

1.5 billion people but also for more of the humanity at large. This is an aspect of change that was seeded by the work of Professor MS Swaminathan. He is seen as the father of the Green Revolution in India. It forms one of the pillars of the impact-making professional contributions of Professor MS Swaminathan. People perceive him as a revolutionist in the field of agriculture and plant genetics.

While industrial farming with socio economic impact is praiseworthy, Earth-sensitive concerns on sustaining biodiversity of Earth cannot be understated. Dr Swaminathan emerged as the champion of sustenance of Biodiversity of the Earth. As the President of the International Union of Conservation of Nature, he argued from change in the Euro to Earth-centric focus. He championed for international protocols on Biosafety under conservation on Biological Diversity. He led the policy formulation leading to the National Biodiversity Act. His four-part formula of biodiversity, namely, conservation, cultivation, consumption and commercialisation of crops presented a new grammar and principle in protection and preservation of biodiversity. People see him as a conservationist. He spoke the grammar of sustainable development and criticality of Sustainable Development Goals much before they became the language of the world.

His life touched the millions of weak farmers and fishers in the complex social order of India. He cared for their livelihood and dignity. His work connected him to women farmers. Gender parity and empowerment were internal calls for him.

He established the MS Swaminathan Research Foundation after his superannuation from the service from formal positions. His prizes and awards became the seed capital of the MSSRF. The foundation carried out groundbreaking work

"Dr Swaminathan remains a phenomenon that occurred in the 20th century. Nature created him for connecting science to the cause of humanity. He remains a Rathna of the Bharath! Long live his memory."

at the interface of science and society helping several farmer communities embrace conservation principles of biodiversity and adopt climate sensitive practices on the ground in normal as well as vulnerable coastal ecosystems with a focus on delivering on key Sustainable Development Goals.

Capacity and skill building among the farmer communities has been his forte. Through his work he touched millions of lives. He became a strong voice of the weak farmers; heard aloud in all public debates and in the corridors of power. To millions of farmers, he was an advocate who spoke for their welfare and farmer's rights. He stood for benefit sharing with farming community as part of social ethics of governance. His role in policy advocacy focused on farmers' and women welfare remains a hallmark.

Hundreds of thousands of scientists saw in him a spokesman and a role model. He spoke for the social contract of science. He carried convictions into his actions. He was a beacon of hope for many youngsters desirous of careers

... World Food Prize Award presented to Dr.M.S.Swaminathan by Mr.Ferguson of General Foods, 6th October 1987 Smithsonian Insitution, Washington, D.C

in science and research. Capacity building and skilling people have been his forte. He championed the cause of science and scientific temper among people. Most scientists and researchers perceive him as a statesman in the science, technology and innovation landscape of India. For generations to come, he has presented a role model to emulate.

Professional contributions of Professor MS Swaminathan made impactful and defining statements in the areas of climate change, sustainability science, delivery on Sustainable Development Goals, biodiversity conservation, nutrition security, Tribal health, gender sensitive governance and many other facets of human life on the Earth. Underscoring all his contributions in professional life is truly his humanism. His ability to connect to people with an extraordinary human sensitivity toned all his professional accomplishments and added extra values. A vast majority of professionals see him as a humanist decorated by his unique and radiating demeanour.

"Professor Swaminathan was seen as a revolutionist, conservationist, advocate, statesman and humanist, all rolled into one. Truly he was all that and much more at the same time."

Professor Swaminathan was seen as a revolutionist, conservationist, advocate, statesman and humanist, all rolled into one. Truly he was all that and much more at the same time. He was a true follower of Gandhi, who said that Science without humanity was sinful. Scientific contributions of Professor Swaminathan had one crosscutting theme namely "science for humanity". His research was not bound by the analytical boundaries of scientific disciplines alone but also focused upon synthesis of implementable solutions to societal problems on the field with farmer centric approaches as working models and farm realities as the governing principle. MSSRF is his brainchild that symbolises his principles and priorities in connecting science to humanity.

Many awards including Padma Vibhushan, World Food Prize, Magsaysay award and many more gained in stature because Professor MS Swaminathan had received them before. Dr MS Swaminathan might not be walking on the planet with flesh and blood anymore but his values for research built on the foundation of universal truth would continue to reverberate for ever. His professional life would always be celebrated. His research ethics emerges directly from universal truth. His work remains emulation worthy for those with internal calls for science for humanity.

In my view, Dr Swaminathan remains a phenomenon that occurred in the 20th century. Nature created him for connecting science to the cause of humanity. He remains a Rathna of the Bharath! Long live his memory.

Dr MS Swaminathan
In Memoriam

Dr Shailesh Nayak
Director, National Institute of Advanced Studies (NIAS), Bengaluru
Former Secretary, Ministry of Earth Sciences, Govt of India

DR MS Swaminathan was a great visionary and an institution builder. His contributions in ushering the 'Green Revolution' were legendary and well-known. The MS Swaminathan Research Foundation, a research institution he created, is in the forefront of wise management of natural resources, conservation of environment, preservation of biodiversity, coastal zone management and sustainable development.

I first met him in the early nineties in connection with the application of Indian Remote Sensing Satellite data for studying coastal environment. He was a very humble, soft-spoken and listened patiently. He had a unique quality of putting people at ease immediately. That was the beginning of our interaction. He supported the use of satellite data in coastal studies, especially assessing conditions of mangroves and coral reefs. The Govt of India issued a notification for regulation of activities in the coastal zone (500 m from high tide line) in 1992. There were many representations to revise the same. The Govt of India appointed a committee under Dr Swaminathan to address these representations and to propose revision of the provisions of this notification, wherever necessary. I was fortunate to work under him for studying the notifications and propose changes wherever necessary. He ensured that the livelihood of fishers and protection of environment were addressed appropriately. Only such approach can lead to sustainability, which was very close to his heart. Today, India is one of the few countries having coastal zone management plans for the entire country's coastline.

"Dr MS Swaminathan was very humble, soft-spoken and listened patiently. He had a unique quality of putting people at ease immediately."

Dr Swaminathan was a great supporter of technology to improve the quality of life. He promoted satellite-based potential fishing zone and sea state advisories among fishers. He used to personally visit many fishing villages to talk to them and explain about the benefits of utilising this information. The use of these advisories not only ensured safety of the fishers but also improved their socio-economic conditions.

"Dr Swaminathan was a great supporter of technology to improve the quality of life. He promoted satellite-based potential fishing zone and sea state advisories among fishers."

He asked me to accompany him during one such visit on the Tamil Nadu coast, so that I could see for myself how judicious use of the technology could help to improve quality of life. The upliftment of the poor, and removal of inequalities were his priorities.

Dr Swaminathan served as the Chair, Council of Management of the National Institute of Advanced Studies, Bengaluru during 2001 to 2013. He inspired the faculty members to carry out research in multidisciplinary research in the field of wildlife conservation, energy and climate change, sustainable development, and strategic and security studies. The NIAS grew many folds during his tenure.

Dr Swaminathan was a scientist of rare distinction, an institution builder, an able administrator, a motivating educator, an alert parliamentarian, and a true world leader. The MS Swaminathan Research Foundation has been a pioneering leader in the field of agriculture, environment and biodiversity, natural resources, and science communication pursuing what he called, "a pro-poor, pro-women and pro-nature approach."

India has lost one of its greatest sons, but he has left a legacy for us to follow the path of sustainability. We will cherish his memories forever. May he rest in eternal peace.

"Dr Swaminathan was a scientist of rare distinction, an institution builder, an able administrator, a motivating educator, an alert parliamentarian, and a true world leader."

An Institution builder who could see far
A tribute to Dr MS Swaminathan

Prof. Anil K Gupta
CSIR Bhatnagar Fellow 2018-21
Founder, Honey Bee Network, SRISTI, GIAN & NIF
Visiting Faculty, IIMA & IITB, Academy Professor, AcSIR

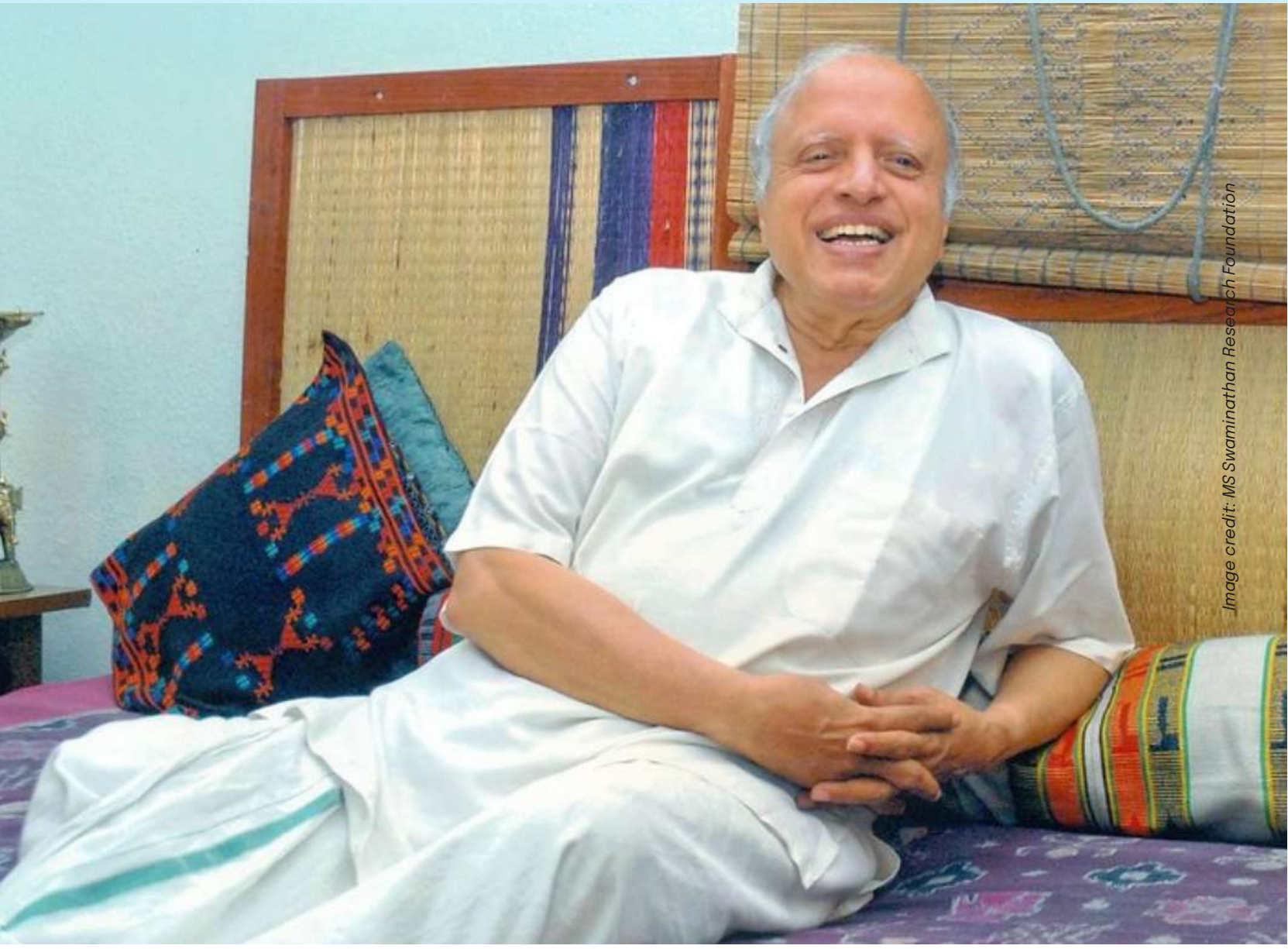


Image credit: MS Swaminathan Research Foundation


Image Credit: flickr

A lot has been said about the contribution of Dr Swaminathan to food self-reliance but not much about intellectual self-reliance. He was a visionary who invited debates on various subjects among inexperienced youth as well as experts. How important debate is to intellectual self-reliance can be understood by those who have had the privilege to argue with him and enjoy disagreements without becoming disagreeable or disrespectful.

I wish to recall some of the very important facets of his personality as a public intellectual. I first met him in 1969-70 as an undergraduate student in a debate among agri-university students. I was representing Haryana Agricultural University along with another student and the debate was in IARI. After winning the second prize, we were sent in a car to Connaught Place to a big book store to buy the books of our choice from the award money. Later, Prof. Swaminathan invited us to breakfast at his Director's bungalow. Shared various thoughts among others for a need to have an association of agricultural students to debate larger questions faced by the country and to participate in the nation building process. On another occasion, we were taken to the Rashtrapati Bhavan to meet President VV Giri.

Encouraging young minds was his lifelong passion. He never made a novice feel insignificant or inconsequential. That was one of his biggest qualities. I am not sure how many feel the same way and relished discussions and debates with him. But I assume there must be thousands like me.

He had a great memory and could recall people's names and sometimes the last conversation he had years ago with ease. That made an instant bond. Everyone with such an experience felt special. To find a small place in his memory bank was a privilege and it made young people feel very confident of their self-worth. They grew several notches higher in that moment.

Let me also recall some of the major conceptual and policy contributions which still merit attention.

In times of drought, the British made a famine code to save lives at minimal cost to the exchequer. But there was no code as to how to leverage opportunities in a good rainfall year. Prof. Swaminathan suggested that measures to conserve rainfall in good weather years were as important, if not more, to deal with stress caused by the floods or droughts. The use of public employment programmes in building water conservation structures before the onset of the monsoon could help mitigate a bad year and use a good year with better preparedness.

"Encouraging young minds was his lifelong passion. He never made a novice feel insignificant or inconsequential."

"Prof. MS Swaminathan had the grace to take criticism in his stride without ever losing his poise and pleasant demeanour. He personified humility and dealt with policy makers as peers and stuck his neck out when needed.

Similarly, he highlighted that in the wake of climate change, the dry spell could occur early, mid or late period of a crop. So, contingency options must be given along with seed bank and nursery of short-duration paddy crop could be kept ready to deal with risky situations to salvage the farmers' economy.

He respected the work of the Honey Bee Network in the area of elevating innovations by farmers and labourers. He recognised the need for 'lab to land' programme to evolve into 'land to lab to land' programme. One could constructively critique his ideas and be given a warm smile of appreciation for the point.

The conservation of agro-biodiversity programme mainly run by women conservators in the secondary source of origin of paddy in the Jeypore tract and Wynand is too well known to repeat here. But he saw the role of women not just as labourers but also as conservators of biodiversity and associated knowledge.

He was a very accessible intellectual giant. If one wanted to meet him and discuss some ideas, it was not very difficult. He was able to think about many policies and programmes that proved worthy in the longer term. Just as there were decisions of his which were controversial. But anyone who fears being ridiculed for his ideas may never be bold enough to break new ground. He had the grace to take criticism in his stride without ever losing his poise and pleasant demeanour. He personified humility and dealt with policy makers as peers and stuck his neck out when needed. He wrote letters to ministers of agriculture advising prudent emergency response when situation so demanded without any fuss. A public intellectual will do so always.

I think there are many lessons one can learn from him but one which in today's world is most important is, never feel shy of sharing your opinion in the presence of top policy makers even if you anticipate rejection of your ideas. What his life teaches is that one in fact earns more respect for being forthright in his commitment to the cause of larger societal good.

Remembering Professor *MS Swaminathan*

Dr RV Bhavani
Dr Bhavani has worked in various positions at the MS Swaminathan Research Foundation, the last being as Director, Agriculture Nutrition Health Programme. She was also on deputation as Officer on Special Duty to the Chairman, National Commission on Farmers.

Image credit: Flickr

THIS piece is being written more than a week since the passing away of Professor MS Swaminathan on Thursday, 28 September 2023. Tributes have poured in from India and abroad in honour of the man acknowledged as the Father of the Green Revolution in India; his many contributions both at the national and global levels, and accolades received have been highlighted. There was an outpouring of grief among many people from all walks of life whose lives he had touched; those who could make it, rushed to pay their respects in person.

Professor Swaminathan (hereafter MSS) had a fair share of critics also and there were rumblings in social media as well. But these were largely overshadowed by the overwhelming sense of loss of a multifaceted personality who made it his mission to work for the eradication of hunger and malnutrition in the world. At a personal level, it has been a period of recollection and reflection on the man and his mission, based on my association of a little over two decades.

In another two years, MSS would have completed a century on the planet. Born in pre-independence India, he was in his early twenties when India gained freedom. He had been offered an academic position in the United States where he had gone on a postdoctoral fellowship. But the young man was clear in his mind that he wanted to work for India's agriculture, and the rest we know is history.

"It was the synergy of science, technology and public policy, and uptake by the Indian farmers, that was instrumental in the success of the Green Revolution, MSS would often say."

MSS it can rightly be said belongs to the league of builders of modern India. In the global arena, he stands tall as a crusader for ending malnutrition in all its forms. The Green Revolution successfully warded off doomsday predictions of hunger and famine and put India on the path to food self-sufficiency. It was the synergy of science, technology and public policy, and uptake by the Indian farmers, that was instrumental in the success of the Green Revolution, MSS would often say. He was also aware of the dangers of overexploitation of natural resources in the race for productivity and profit, that is highlighted by many critics of the Green Revolution, and had warned of the consequences as early as in the late 1960s itself. And he went on to expound the concept of Evergreen Revolution based on sustainable use of natural resources.

MSS's years at the Indian Agriculture Research Institute (IARI) and later at the helm of the Indian Council for Agricultural Research (ICAR) saw pathbreaking research in agriculture as well as significant institutional initiatives. These have been recorded by his biographers and some of his students. Among the many notable initiatives he steered during this period, was the establishment of the Indian Agricultural Research Service[1].

The idea of an institution on the contours of the MS Swaminathan Research Foundation (MSSRF) that he went on to establish in 1988, go back many years. Tracing the genesis of MSSRF, MSS recorded in his introduction to MSSRF's Annual Report (2011-12)[2]: "It was way back in 1970 that Professor CV Raman seeded the idea in my mind that I should be involved in establishing a research and training centre in

1 https://www.mssrf.org/small-news/breeding-brains-for-a-hunger-free-india-prof-m-s-swaminathan/

2 http://59.160.153.188/library/sites/default/files/AR2011-2012.pdf

Image Credit: worldfoodprize.org

"MSS was also a strong advocate for food-based approaches for nutrition security as against drug-based approaches."

the field of applied ecology, relating to the improvement of the productivity, profitability and sustainability of small-farm agriculture." He was writing the section before stepping down as Chairman of the MSSRF Board of Trustees and shared his vision for sustainable rural development. MSS continued to be on MSSRF's Board as Founder Chairman, till the end.

MSS was awarded the first World Food Prize[3] in 1987 and used the prize money to establish the MSSRF[4]. It was in July 2000 that I first met him. I had applied for a position at the MSSRF and was called for an interview. While I waited, he suddenly walked in and introduced himself with a smile — 'Swaminathan'! This unassuming simplicity and humility were hallmarks I witnessed on many occasions thereafter. I left my job as a bank officer to join MSSRF. There had apparently been some debate among the members of the interview panel if I would fit in and stay on, but he had been in favour of my joining, MSS said during one of my visits to see him about a year ago. Age had begun to take its toll, he was physically weak, unable to sit for long, and his voice had become feeble, but his mind was alert and sharp till the very end.

It was thus that in September 2000, I began a learning journey working with MSS at MSSRF. The Green Revolution had brought food security to the country, but the greater challenge now was to realise nutrition security. MSS began advocating early on for nutrition security based on a lifecycle approach. He defined nutrition security as: "physical, economic, and social access to balanced diet, clean drinking water, sanitation and primary healthcare"[5]. Under his guidance, and with support from the UN World Food Programme (UNWFP), MSSRF undertook to map the rural, urban, and environmental sustainability of food security in the country. The reports formed the basis for discussion under his call for 'Mission 2007: Hunger Free India', as the country approached the 60th anniversary of independence. A series of regional and national consultations on this theme were organised across the country during 2005-2006, jointly with UNWFP and the National Commission on Farmers (NCF). These fed into the recommendations in the NCF reports to address food and nutrition security.

MSS was also a strong advocate for food-based approaches for nutrition security as against drug-based approaches. Way back in 1978, when he was at the helm, ICAR had produced a publication titled, *A Plan to Combat Malnutrition — Nutrition Gardens*. Taking this forward, he called for mainstreaming the nutrition dimension in agriculture to address malnutrition and coined the term 'Farming System for Nutrition–(FSN)', defining it as: 'the introduction of agricultural remedies to the nutritional maladies prevailing in an area through

3 https://www.worldfoodprize.org/en/laureates/19871999_laureates/1987_swaminathan/

4 www.mssrf.org

5 https://www.mssrf.org/small-blog/moving-from-food-to-nutrition-security-prof-m-s-swaminathan/

Image Credit: worldfoodprize.org

"A passionate scientist at heart, MSS was always curious to hear from the younger generation of scientists and researchers and keep himself abreast with the latest developments."

mainstreaming nutritional criteria in the selection of the components of a farming system involving crops, farm animals and wherever feasible, fish'[6]. From 2013 to 2018, when he was into his 10th decade, MSS chaired the Consortium Advisory Group of a UKAid supported multi-country, multi-institutional research programme consortium — Leveraging Agriculture for Nutrition in South Asia (LANSA), that was led by MSSRF, and provided guidance in operationalising the concept of FSN[7] and in policy advocacy for nutrition-sensitive agriculture.

MSS was 75 when I started working at MSSRF, but his energy levels were amazing. Meticulous in taking notes in long hand, action points from meetings he chaired would be produced almost immediately. A stickler for punctuality, when he was not travelling, he would be in his office at the Foundation by 9 am. Any important issue to be discussed would be over tea at 11 am, a practise I understand he followed from his days at IARI. His secretary would call to inform in the morning, and we would head to the canteen, notebook in hand, for 'Tea with Prof'. The matter discussed, a mail would follow immediately on steps to be taken. He always paid for the tea; he also always had a smile or a word for others present.

MSSRF regularly organised many national and international consultations under his oversight. He would designate an organising secretary and committee, provide advice as required and give a free hand for operationalising the arrangements. A man of tremendous calm, he would quietly observe and come and ask, "Is everything under control?", to get a sense of how matters were progressing. The same applied to project implementation. He would carefully read reports shared with him and immediately give feedback. He would sometimes even come to our desk to discuss a matter, instead of calling us, such was the man!

Among many significant meetings hosted by MSSRF under his leadership was the 30th Session of the UN Standing Committee on Nutrition (SCN) in 2003, the first time in SCN's history that their annual session was hosted by a civil society organisation[8]. MSSRF was also the venue of meetings chaired by MSS that paved the way for two important national legislations, viz. the Protection of Plant Varieties and Farmers' Rights Act 2001 and National Biodiversity Act 2002.

A habit MSS had long cultivated was to personally respond to all correspondence addressed to him, regardless of who it came from. A familiar scene at MSSRF was to see

6 https://www.currentscience.ac.in/Volumes/107/06/0959.pdf

7 http://59.160.153.188/library/sites/default/files/Farming%20system%20for%20Nutriion.pdf

8 https://www.unscn.org/files/Annual_Sessions/30th_SCN_Session/30th_session_REPORT.pdf

him sitting in his secretariat dictating to his secretaries, as they typed. He would also prepare for any address he was to give, with care. The scientist and researcher in him made him continue to guide doctoral research students and it was as late as in 2017 that his last student submitted her thesis. A passionate scientist at heart, MSS was always curious to hear from the younger generation of scientists and researchers and keep himself abreast with the latest developments. He would often make his way to the laboratories at MSSRF to see the scientists at work. MSS conceptualised and launched the 'Every Child a Scientist' programme at MSSRF[9] targeting children from government and aided schools. A programme of Genome Clubs promoted in schools to promote genetic literacy was expanded in 2007 into a national programme of DNA Clubs under the Department of Biotechnology (DBT), Government of India (GoI)[10]. In 2001, with support from the government of Tamil Nadu and DBT, MSSRF established the first women's biotechnology park in the country, to encourage women scientist entrepreneurs[11].

A humanist at heart, MSS's immediate connect with people was clearly visible when he visited MSSRF's field centres and interacted with rural men, women, and children. A firm believer in people's participation, engagement, and empowerment, he coined terms such as, 'Community Hunger Fighters'[12], and the like, to give them recognition; grassroot champions were recognised as Fellows of the National Virtual Academy for Rural Prosperity[13] that he established.

MSS saw in ICT an important tool for accelerating rural prosperity, and came up with the idea in the early 1990s of reaching the unreached by establishing Village Knowledge Centres (VKC), to provide demand-driven, need-based information to rural communities. Subsequently, in collaboration with ISRO, MSSRF went on to set up Village Resource Centres with satellite connectivity. The initiative expanded in 2004 to a national alliance under the banner 'Mission 2007: Every Village a Knowledge Centre'. Responding to the momentum generated, GoI announced a budget allocation in 2005–2006 for setting up VKCs across the country, followed by the Common Service Centre initiative in 2006–2007 as part of the National e-governance Plan.

In 2004, MSS was appointed Chairman of the NCF constituted by GoI for a two-year term. There had been Commissions on Agriculture earlier; this was the first time the 'Farmer' was the centre of focus. I got the opportunity to work in the NCF as Officer on Special Duty (OSD) to the Chairman. Even as office infrastructure for the members and logistics were still being worked out, MSS proposed that the Commission submit its first report in December itself and set a fast pace of work. When the tsunami struck on 24 December 2004, he immediately convened a meeting and a chapter titled, "Beyond Tsunami: Saving Lives and Livelihoods" was added to the report. Even as the suffering caused by any calamity is painful, his dictum was that we should use the opportunity to learn and ensure that such eventualities do not recur.

The NCF went on to submit five reports under the generic title — 'Serving Farmers and Saving Farming', and a draft National Policy for Farmers. In October 2005, he led field trips of the NCF to Punjab, and the Vidarbha region of Maharashtra, to understand the ground situation by interacting with farm men and women, besides engaging with government officials, scientists, and other stakeholders. In Vidarbha, we also visited families of some of the farmers who had committed suicide. Recommendations to address the agrarian crisis were made in the third Report of the NCF submitted in December 2005. The experience also triggered immediate action from MSS by way of MSSRF launching a programme of education support to the children of farmers who had committed suicide, so that their studies are not disrupted. It was decided to start the initiative in Wardha district and the programme was rolled out in 2006. Simultaneously we reached out to the mothers of the children and following interaction with them, it was decided to start an initiative to empower women farmers by strengthening their capacities under the name *Mahila Kisan Sashaktikaran Pariyojana* (MKSP). This became a national programme in 2010-11 with GoI making it a sub-component of the National Rural Livelihood Mission under the Ministry of Rural Development. These were lessons on demonstrating in action and engaging in policy advocacy for impact at scale[14].

MSS remained equanimous and accessible, despite being the recipient of many awards and honours. "When being lauded, I tell myself they are praising someone else", he would say with a smile! An epitome of perseverance, I have been able to highlight here just some aspects of the humane and versatile personality that MSS was, and his numerous contributions. He was one of his kind and his legacy will live on through the institutions he built/guided and initiatives he steered. His is a life to cherish and strive to emulate. These lines by the Austrian poet Rainer Maria Rilke seem apt as we pay homage and celebrate the life of MSS:

Again and again in history
Some special people wake up
They have no ground in the crowd
They move to broader laws
They carry strange customs with them
And demand room for bold and audacious actions
The future speaks ruthlessly through them
They change the world!

9 https://www.mssrf.org/ongoing-projects/every-child-a-scientist-programme/#:~:text=ECAS%20programme%20at%20MSSRF%20was,the%20lessons%20from%20this%20programme.

10 https://nasi.org.in/dna-club/

11 https://www.biotechpark.co.in/

12 https://www.mssrf.org/small-news/strengthening-the-community-hunger-fighters-approach-for-odisha/; https://www.youtube.com/watch?v=t7E-XN6Fmk0&list=PLzBW9IguAXpZSL7h0HY6f_KYDYUmCWLIP&index=6

13 https://www.mssrf.org/small-news/jamsetji-tata-national-virtual-academy/

14 https://www.youtube.com/watch?v=NN2waQl7p54&list=PLzBW9IguAXpZSL7h0HY6f_KYDYUmCWLIP&index=1

The Century-Old Mansion in Birla Park Home to BITM Kolkata

Jayanta Sthanapati

The Birla Industrial and Technological Museum, nestled in a century-old mansion in Birla Park, is the nation's first industrial and technological museum. Ghanshyamdas Birla acquired the property in 1919 and following Bidhan Chandra Roy's suggestion, donated it partly to the Government of India to establish the museum. The roots of this iconic institution can be traced back to 1923, precisely a century ago. The Birla Industrial Technological Museum (BITM) continues its legacy of inspiring young minds through exhibits and activities to foster innovation.

THE Birla Industrial and Technological Museum, commonly referred to as BITM, located in Kolkata, is situated in a magnificent century-old mansion nestled within the prestigious Birla Park. This museum commenced its operations sixty-four years ago, in 1959, marking a significant milestone as the nation's foremost science and technology museum. Interestingly, the roots of this iconic institution can be traced back to 1923, precisely a century ago, when Ghanshyamdas Birla, an industrialist, constructed this building on a plot spanning 19 bighas of land.

Born in Pilani, Rajasthan, GD Birla arrived in Kolkata at the age of eighteen in 1912 with aspirations of venturing into business endeavours. Initially facing challenges while establishing his presence among Kolkata's flourishing Rajasthani business community, he eventually showcased remarkable business acumen that propelled him to prominence among the city's leading entrepreneurs during World War I. By the young age of twenty-four in 1918, he successfully established Birla Brothers Pvt. Ltd with an investment amounting to fifty lakh rupees — a testament to his financial achievements. The following year he acquired the property located at 18 Store Road, presently recognised as the location of BITM, intending it to serve as a residence for his extended family and named it 'Birla Park'.

Birla Park Mansion in the 1950s (above) and now

The Residence of Tagores and Birlas

In 1919, GD Birla acquired the property from Surendranath Tagore for four lakh rupees. It is worth noting that Surendranath purchased this property from Mirza Abdul Karim and eight other owners in 1898. Although there is limited documented evidence regarding previous ownership of the property, an original Calcutta Corporation plan dating back to 1907-1908 attests to its partial construction as a two-storied and three-storied building, with ponds on its northern and eastern sides. After the Birlas acquired the property, significant transformations took place, including the demolition of the previous residence occupied by the Tagores. GD Birla then appointed Architects N Guin and Co. to design the structure that stands today, showcasing a colonial adaptation of diverse European architectural styles (*Birlas and a Great Service to the Cause of Science* — An interview of Basant Kumar Birla and Sarla Birla, by Jayanta Sthanapati and Indranil Sanyal, published in 'Birla Industrial and Technological Museum: 1959-2009' 29-31; 2009).

Prior to GD Birla's occupancy, Surendranath Tagore resided within

these premises alongside his family for approximately two decades. In 1982, Mihirendranath Tagore, son of Surendranath Tagore, visited BITM and reminisced about leaving 19 Store Road at the tender age of five. He recalled the presence of a spacious entrance gate flanked by expansive lawns and described the building as being three-storied. During their tenure, his parents occupied the first floor while his grandparents resided on the second floor.

Amidst his residency here, Surendranath played a significant role in financially supporting extremists during the freedom movement. He also served as treasurer for a committee aimed at unifying revolutionary forces in Bengal under Pramathanath Mitra's leadership. Prominent individuals such as Chittaranjan Das and Aurobindo Ghosh conducted operations from this residence. Furthermore, Satyendranath Tagore, Surendranath's father, extended invitations to esteemed members of Congress, including Surendranath Banerji, Rashbehari Ghosh, and Anandamohan Sen, for gatherings held at their residence. These occasions were graciously hosted by Surendranath's mother, Jnanadanandini Devi, who held progressive views on women's emancipation.

Under Birlas' ownership, Birla Park retained its exceptional reputation as an esteemed address that welcomed distinguished personalities such as Mahatma Gandhi, Motilal Nehru, Lala Lajpat Rai, Jawaharlal Nehru, and Pandit Madan Mohan Malaviya. Informal meetings of the Congress party and discussions involving individuals central to transformative political and social movements took place within these walls. Notably, this location facilitated a meeting between Chiang Kai-shek and Gandhiji, enabling them to engage in meaningful conversations.

There is an interesting story behind the change in postal address of the premises, which currently house the BITM, from '18 Ballygunge Store Road' to '19A Gurusaday Road'. Until 1942, what is now known as Gurusaday Road was referred to as Ballygunge Store Road, named after a general store located at Tivoli Court during Mirza Abdul Karim's ownership of the property. The address of the premises was initially '18 Ballygunge Store Road' and later changed to '19 Store Road' when owned by the Tagores. In 1942, it was renamed Gurusaday Road in honour of Gurusaday Dutt's contributions to Bengal's folk culture revival. In 1958, an 'A' was added to the address by Calcutta Corporation, resulting in its current listing as '19A Gurusaday Road' (*19A Gurudaday Road — Formerly the home of the Tagores and Birlas and since 1959, it has been a museum of sciences,* BITM publication, 1983; research conducted by Ketaki Mitra, Junior Research Fellow at BITM).

Vision for an Industrial Museum at Birla Park

In the early 1950s, the senior members of the Birla family at Birla Park thought of gifting the house for public use. The suggestions were to convert it into a hospital, a boarding house, a museum of some sort or an industrial museum. Bidhan Chandra Roy, an eminent physician and former Vice-Chancellor of the University of Calcutta was the Chief Minister of West Bengal then. During one of his European tours in the late 1930s, BC Roy had the occasion to visit the world-famous Deutsches Museum in Munich. It impressed him greatly, and he cherished a keen desire to establish a technological museum in Calcutta. Incidentally, BC Roy was a family physician of GD Birla for about three decades and thus visited the house at Birla Park many times. So, when GD Birla told him of their wish to hand over the building to the Government of India for a noble cause, he lauded the Birlas and suggested transforming it into an industrial museum.

In December 1954, GD Birla wrote to Maulana Abul Kalam Azad, the then Education Minister and the Vice-President of the Council of Scientific and Industrial Research (CSIR), expressing his desire to transfer a part of Birla Park, including the mansion thereon, to the Government of India for establishing an industrial museum by the CSIR. Maulana Azad soon endorsed the proposal and then got the approval of Jawaharlal Nehru, Prime Minister, who in turn constituted a committee with BC Roy as Chairman to specify the scope and function of the proposed museum (Amalendu Bose. *Birla Industrial and Technological Museum — in Perspective*. In 'Museum of Science', BITM Publication, 3-12; 1983).

The magnitude of this museum facility was truly noteworthy, comprising forty rooms, seven sprawling halls, and five bighas of surrounding space within the esteemed Birla Park premises. With foresight towards future growth, an additional land area equivalent to five bighas was subsequently allocated for potential expansion. The conversion of this historically significant and opulent residence into a public museum was executed expeditiously. GD Birla oversaw the transformation of forty rooms into eleven halls to accommodate museum galleries, resulting in a total of eighteen halls within the premises.

Initiating the Establishment of BITM

The Museum Committee formed by the Prime Minister convened its inaugural meeting at Birla Park on 5 February 1955, with Bidhan Chandra Roy presiding as Chairman. Notable members present included Jnan Chandra Ghosh, Vice-Chancellor of the University of Calcutta, GD Birla, and a senior official representing the Vice-President of CSIR. During this meeting, a crucial decision was made to appoint a Planning Officer tasked with expediting the establishment of the proposed industrial museum within the mansion at Birla Park.

After a fortnight, K Biswas, a senior government official from West Bengal, who had extensively travelled across Europe and visited numerous science and industry museums, submitted a comprehensive scheme for setting up an Industrial Museum to BC Roy, Chairman of the Museum Committee. The scheme proposed ten sections encompassing Industries for Vegetable Products; Industries from Animal Products; Machine-tools Industry; Metallurgical Industry; Ceramic Industry; Electrical Industry; Postal Industries; Earth Products; River Valley Project and Industrial Development; and finally, Mining and Engineering Developments.

Biswas also provided recommendations for the museum's administrative and financial structure.

Significantly, on 29 January 1956, GD Birla formally presented the title deed for a designated portion of Birla Park, measuring 19 bighas and including the mansion, to Prime Minister Jawaharlal Nehru in New Delhi. Subsequently, Nehru passed it on to MS Thacker, who served as the Director General of CSIR.

Another development plan was submitted to BC Roy on 24 July 1956 by Ramanatha Subramanian, Officer-in-charge of the Science Museum at the National Physical Laboratory in New Delhi. Subramanian suggested establishing a Science and Industry Museum at Birla Park with eighteen sections covering subjects such as Chemical Industries; Electrical Engineering; Mechanical Machinery; Textile Industry; Mining and Metallurgy; Land, Water and Air Transport; Electricity and Magnetism; Telegraphy and Telephony; Typewriting and Printing; Photography and Cinematography; X-rays, Ultraviolet Rays and Infrared Rays; Electronics Broadcasting and Television; Atomic Physics; Optics; Paper Manufacture; Weights, Measures, Mechanics, Acoustics, Heat and Energy; Petroleum Industry; Dyes, Soap, Plastics and Rubber.

In the meantime, Jawaharlal Nehru, who was also the President of CSIR, made the prudent decision to designate the proposed industrial museum as 'Birla Industrial and Technological Museum'. Furthermore, in November 1956, Amalendu Bose, a Patent Inspector with a background in Chemistry from Calcutta and New York, was appointed as the Planning Officer of BITM. Bose carefully reviewed the proposals submitted by K Biswas and R Subramanian to BC Roy for consideration for the museum.

On 19 January 1957, A Bose presented his draft scheme for setting up BITM at Birla Park to the members of the Museum Committee presided over by Bidhan Chandra Roy. Other notable committee members included Jnan Chandra Ghosh, a member of the Planning Commission; Braj Mohan Birla, brother of GD Birla; MS Thacker, Director General of CSIR; JC Sengupta, Chief Botanist at the Botanical Survey of India; DF Macmillan representing the Bengal Chamber of Commerce; JW Whitaker, Director of Mining Research Institute; W O'Dea, Keeper at Science Museum London; VP Beri, Curator at Central Museum Pilani; and Moti Lal, Financial Advisor at CSIR.

Following thorough deliberations, the Museum Committee approved A Bose's draft scheme for BITM, which aimed to showcase recent technological advances, the contribution of technology to human welfare, and the application of modern methods in select Indian industries. The proposal included establishing ten distinct sections for the museum galleries: Communication; Electric Power Generation; Electric Power Transmission; Nuclear Physics; Transportation; Optics; Civil Engineering; Textile Engineering; Chemical Technology; and Mining & Metallurgy. Additionally, the proposal suggested converting sixteen renovated halls into galleries. The remaining two halls in the building could serve as an auditorium and a library.

Recognising the significance of passionate individuals in this field, A Bose began recruiting officials and experts from various relevant subject areas to create the museum from 1957 onwards. They decided to set up museum galleries based on the subjects covered by the proposed branches of technology and taking into account available models and space. The museum received several models and exhibits as gifts from industrial houses in India, the UK, West Germany, France, Holland, Sweden and the USA. An important step taken by the planning authority of BITM was to set up a fully equipped workshop for the fabrication and repair of exhibits. The BITM engineers engaged persons with aptitude in model making and fabricated many exhibits in-house.

To support capital and recurring expenses during the Second Five-Year Plan period (1956-1961), the Planning Commission allocated Rs 20 lakhs to BITM. Remarkably, within a span of just fifteen months, the museum was ready for opening — featuring thematic indoor galleries centred around Electricity; Metallurgy of Copper, Iron, and Steel; Petroleum; Nuclear Physics; Optics and Miscellaneous Topics; Electronics; as well as a Television Studio.

The Dream Comes True

The dream became a reality on 2 May 1959 when Humayun Kabir, Union Minister for Scientific and Cultural Affairs, inaugurated Birla Industrial and Technological Museum at 19 Gurusaday Road, Kolkata. The inaugural ceremony was graced by BC Roy, Chief Minister of West Bengal; MS Thacker, Director-General of CSIR; BM Birla representing the Birla Family; A Bose, Planning Officer of BITM; academicians, leading citizens, industrial magnates, and members of the press.

Since its inauguration, the museum has emerged as an iconic landmark in Kolkata! It has played a pivotal role in spearheading the popularisation of science throughout the country and continues to serve as a beacon for scientific awareness even today.

In 1978, BITM came under the administrative control of the newly formed National Council of Science Museums (NCSM) under the Ministry of Education and Culture of the Government of India after being delinked from CSIR.

BITM is a testament to the vision and unwavering dedication displayed by Ghanshyamdas Birla, Bidhan Chandra Roy, and CSIR. The museum presents diverse exhibits, artefacts, interactive displays, and educational programmes that inspire young minds while nurturing innovation. Visitors have the opportunity to explore various domains encompassing science and technology. Furthermore, BITM offers workshops and seminars that establish a platform for students and teachers to engage in idea exchange and collaborative projects.

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PRINTING IN THREE DIMENSIONS

Nimisha Vaidya

IN the not-too-distant past, a patient in dire need of an organ transplant had to wait for someone to die to be bestowed with a healthy organ and thus, a new life. Today, an organ can be printed in a laboratory, with perfect specifications matching the patients' needs and successfully implanted in his body. This is the most recent and best application of 3-Dimensional Printing technology currently in use, though this technology is certainly not limited to the medical field. Its scope is bounded only by the limits of one's imagination.

It was Charles Hull, a physicist, who patented the 'stereolithography' technique, now commonly known as 3D printing, in 1986. He thought of this process while using ultraviolet light to harden coatings on a tabletop, in 1983. The new designs in manufacturing plants which required small parts hindered the speed of the process until his invention. Hull then started a company called 3D Systems and expanded his patents to include non-liquids. Vehicle manufacturing companies and medical and non-medical R&D labs were immediately attracted by the infinite possibilities posed by this invention. In 2014, Hull was inducted into the National Inventors Hall of Fame. He is also known as the "Father of 3D printing".

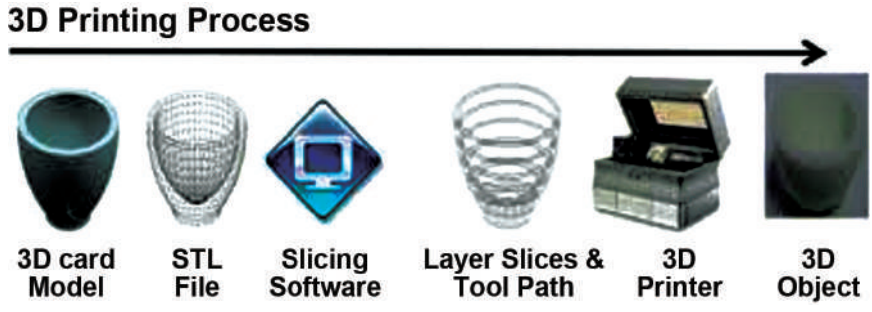
3D Printing Technologies

The basic steps to create a 3D printed object are as follows:

1. Imagine an object
2. Create its computerised image
3. Using the slicing software, divide this image into different parts horizontally
4. Choose the material and the appropriate printing technology
5. Print the object
6. Apply post-processing techniques if required, to refine the object

Additive manufacturing techniques can be categorised based on different criteria, such as, material used, types of products, the process, etc. The International Standards Organisation [ISO] has divided them into seven main classes so that the structure remains uniform across the world. The classification is as follows:

1. Material Extrusion
2. Vat Polymerisation
3. Powder Bed Fusion
4. Material Jetting
5. Binder Jetting
6. Directed Energy Deposition
7. Sheet Lamination



The 3D printing process

Timeline of Development of Additive Manufacturing Techniques

1981 — First 3D printing patent awarded to Hideo Kodama of Japan. He invented a device that used UV light to harden photoreactive polymers.

1984 — Charles Hull patented the 'stereolithography' technique. He developed the STL file format which are digital files that can be read by 3D printers.

1987 — Carl Deckard filed a patent for a 3D printing technology known as Selective Laser Sintering [SLS], which is widely used for models and end-use parts in various industries.

1988 — Fused Deposition Modelling technology invented.

1989 — GMbH, a German Additive Manufacturing company developed a process called Direct Metal Laser Sintering [DMLS] for 3D printing. This is the only technology capable of producing entirely metal parts.

1989 — S Scott Crump developed and patented Fused Deposition Modelling [FDM], the technique of 3D printing that is so simple and easy to use that it revolutionised the industry so that common people could use it in their homes to 3D print objects.

2001 — First Desktop 3D printer manufactured.

2002 — First human kidney 3D printed.

2005 — The Reprap project is founded by Dr Adrian Bowyer. This is a 3D printer which can print its own parts, to replicate itself.

2008 — First prosthetic leg 3D printed.

2011 — The first 3D printed edible food is created.

2013 — The first 3D printed rocket parts are printed by SpaceX.

2014 — NASA flies first zero-gravity 3D printer into space.

2014 — First 3D printed house built.

2017 — First 3D printed farms.

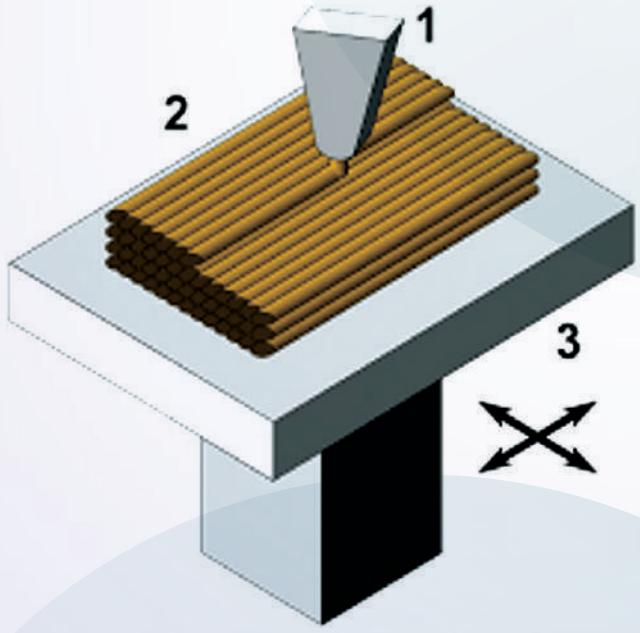
2018 — First 3D printed glass.

Material Extrusion: This process can be thought of as similar to the hot glue gun. Extrusion is a practice of forming something by pushing it out through a small aperture. A filament of materials such as metals, plastics, concrete and even biomaterials is fixed on a bobbin. This bobbin is then loaded into the 3D printer. The materials are pushed through a heated spout so that they are near melted when they come out of the spout. The printer deposits this paste onto a build platform, guided by the design software.

As the printer moves the spout along the specified coordinates on the XY plane, it lays down the first layer. The extrusion head is then moved vertically to the next level height (the Z plane), and this process of printing cross-sections is repeated, building layer upon layer until the object is fully formed. The material cools down to form a solid object. Depending on the geometry of the object, it is sometimes necessary to add structures to support the model as it is being printed. These supports are eventually removed. Some support structure material is water soluble or sometimes requires another solution to dissolve.

The subtypes of this method are Fused Deposition Modelling [FDM], Construction 3D printing, Micro 3D printing, Bio 3D printing, etc. The process being same in these techniques, the only difference is in the type of materials, the size of the spout and consequently, the size of the printer.

The 3D Bio-printers use materials called bio-inks, mainly made up of living matter such as collagen, gelatin, living cells, etc. printed onto a platform through fine needles. In contrast, the construction 3D printers are large scale in terms of size and weight. A robotic arm system pushes material like cement onto a huge spout to create buildings. The Indian army has constructed the first 3D printed dwelling unit in Ahmedabad using this technique, as reported on 29 December 2022 in *The Economic Times*.



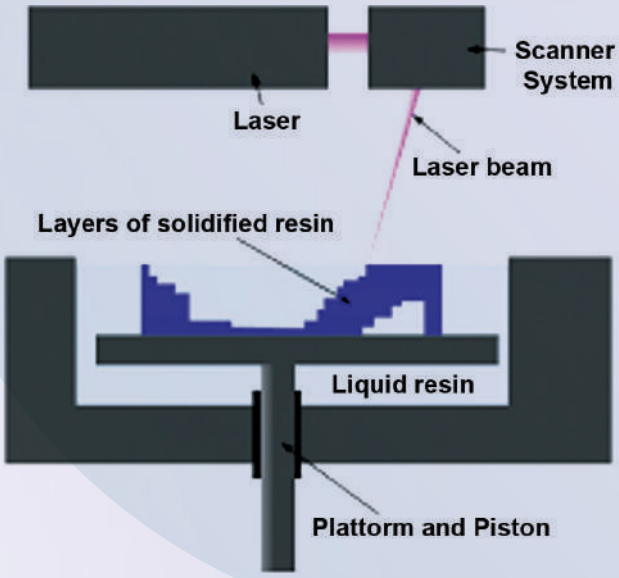
Fused deposition modeling

A house 3D printed by Indian Army in Ahmedabad

While this is a versatile method that can be used to build a wide range of structures, ranging in size from microscopic to mega structures, and can effectively use an extensive range of materials, it has a few drawbacks. The precision of structures created by this method is not cent percent, and the strength and durability are also not up to the standard specifications. The cost varies depending on the size of the printer.

Vat Polymerisation: Polymerisation is a technique in which small molecules, usually known as monomers, combine using chemical processes to produce a network or chain. This long chain of monomers is known as a polymer. In case of 3D printing, a large tank, called a vat, is filled with liquid resin. This resin is hardened layer by layer using a light source which is guided by a slicing software. The hardening process is known as curing. The build platform is moved vertically to cure each layer, about 0.01–0.05 mm at a time. After the curing process, the object is cleaned to detach the remaining liquid resin. In some cases, post-processing by sunlight or UV light is applied to boost the mechanical properties of the object.

Stereolithography (SLA), Digital Light Processing (DLP) and Liquid Crystal Display (LCD) are the most common forms of Vat Polymerisation. The basic difference between these techniques is in the light source used and the processing used to harden the resin. While SLA uses a solid-state laser light source, microSLA uses a UV laser and DLP uses a digital light projector containing an array of LEDs. In addition, other optical components like micromirrors and lenses are used to refine the process. Projection Micro Stereolithography (PμSL) is another technique belonging to this type which is fast growing due to its low cost, accuracy, speed, and also the range of materials that it can use, which include polymers, biomaterials, and ceramics.



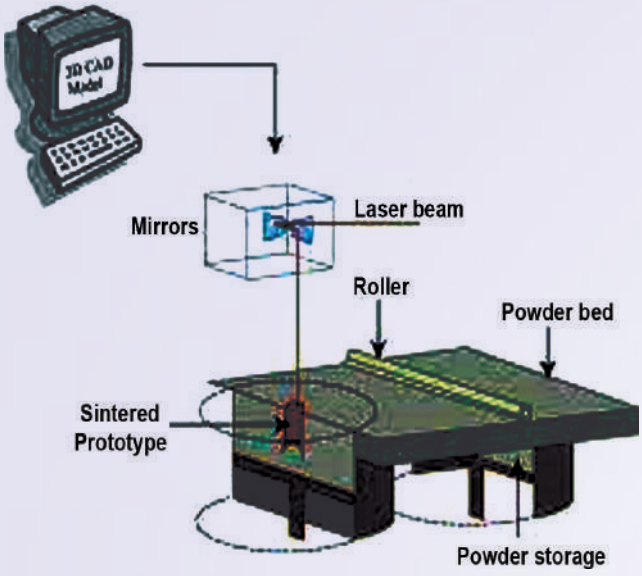
Stereolithography

The dimensional accuracy achieved with this process is quite good and the finished product is exquisite in terms of smoothness and fine details. Thus, these processes are extensively used for applications like jewelry casting, dental applications and allied medical fields. SLA is used to create prototypes for products used in medicine or computer hardware fields. This technology yields smooth surface finish, fine feature details and is quite fast. Its applications include research, medical applications like tissue engineering and manufacturing tiny parts, such as micro-sized electrodes, surgical tools and micromechanical parts and optical sensors.

Powder Bed Fusion: As the name suggests, there is a build area called a bed, filled with a powder of chosen material. This powder can be of plastic, metal or a ceramic, though some techniques also use metal nanoparticles. The build chamber is sealed and either filled with inert gases such as nitrogen or is evacuated. Then, a suitable energy source, which is either a thermal gun, a laser or an electron beam, selectively melts the powder particles layer by layer, to create a pre-designed structure. The final article is supported and enclosed by the unfused powder, which is then removed by post-processing. The unfused powder can be reused for the next printing, which helps to minimise losses. The article is then polished, coated or coloured as per requirement.

This technology is generally used by industries which manufacture functional parts of machines used in aviation industry, motor parts and dental and medical engineered equipment such as implants and prosthetics and those for industrial use. Titanium orthopedic implants, copper coils and turbine blades for jet engines are examples of articles which can be created using this technology.

Selective Laser Sintering (SLS), Laser Powder Bed Fusion (LPBF), and Electron Beam Melting (EBM) are examples of processes using this technology. These techniques differ in the material and the type of energy source used.



Selective Laser Sintering

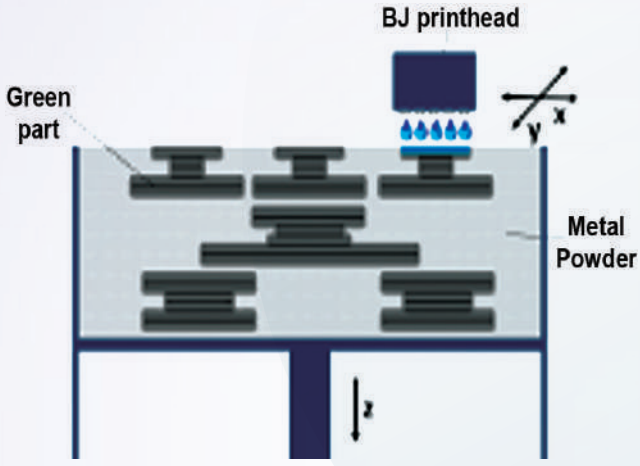
The objects created with these processes are very precisely made and they have exceptional mechanical properties and highly complex geometries. The major shortcomings of this technology are that the printers of this category are very expensive, use high-cost materials and the production rate is very slow.

Material Jetting: This technology is used when it is required to create objects using different types of materials or when different parts of an object are required to be having varied colours and textures. The process needs a build platform on which tiny droplets of material are deposited and then solidified, layer by layer, guided by the slicing software. The materials could be photopolymer resin or wax. The solidification is done by exposing the material to UV light. This process renders a textured surface finish and also allows for colouring parts in different colours. Unlike other techniques, articles printed by this technology do not require post-curing, as the UV light in the printer itself cures each layer as it is being printed. But this technique can be used only for a limited range of materials and is also quite expensive compared to other techniques. The articles, while being manufactured by this technology, require support, which is printed from a dissolvable material. This material is removed during post processing stage.

The different processes using this technology are Material Jetting (M-Jet), Nano Particle Jetting (NPJ), Aerosol Jetting and Plastic free forming. All these processes vary in the materials used and the type of printers.

This technology finds a variety of applications in diverse fields. While the Aerosol jet is used to print both active and passive electronic components like resistors, capacitors and thin film transistors, the M-Jet technology is used by automobile manufacturers, industrial design firms, art studios and even by medical equipment manufacturers to create prototypes for testing.

Binder Jetting: This technology is a fusion of powder bed technology and material jetting. A blade spreads a thin layer of powder material on a build platform. The material can be metal, sandstone, gypsum, plastic, ceramic, wood, sugar, polymers, etc. Accordingly, the various processes are named Metal Binder Jetting, Polymer Binder Jetting, Sand Binder Jetting, etc. A printhead, with an inkjet nozzle, passes over this layer and deposits droplets of a suitable binding agent at selected places so as to glue the particles together at those places. Again, another layer of powder is deposited by the blade, which is selectively bounded. This process keeps on repeating until the entire structure is created. The excess powder is removed after the structure is built and can be reused in most cases.



Metal Binder Jetting

This technology can be used with a wide range of materials, is quite inexpensive and fast, and is able to produce large volumes of parts more cost effectively. Binder jetting is used when solid metal objects with complex geometries are to be created. The only limitation of this process is that it requires a variety of post processing techniques to be applied to the article for it to enhance its mechanical strength. The articles are given heat treatment in a furnace and sometimes fused with other metal to make it non-porous.

Construction industries, medical field, automobile manufacturers, etc. use this technology to create sand casts, medical implants, molds, functional metal spare parts, full colour models, and so on.

Direct Energy Deposition: This is one of the broadest classes of 3D printing technology which includes a variety of subclasses depending on the form of material and the type of energy. It is analogous in a way to the welding process, as metallic material is fused by powerful energy as it is being deposited. Although it is also used to print an object layer by layer as in other technologies, its wider use is for repairing or adding extra features to an existing metal article. Usually, the process is followed by CNC machining (CNC = Computer Numerical Control) to increase the tolerance.

The type of energy used to fuse the metal to create a structure is the criteria for classifying this technology. Powder Laser Energy Deposition or Laser Direct Energy Deposition (L-DED), Wire Arc Additive Manufacturing (WAAM), Wire Electron Beam Energy Deposition or Electron Beam Direct Energy Deposition, Molten Direct Energy Deposition and Cold Spray are the subtypes of this technology.

L-DED uses a powerful beam of laser to weld metal, whereas the Electron Beam process employs a concentrated beam of electrons for this purpose. While these two methods require sealed and vacuum chambers respectively for producing impurity free, high-quality metal, the other methods do not require either of these.

Metal in powder or wire form is deposited on a build plate. This could be placed on a multiple axis turntable to enable it to move in all directions. The energy source is directed onto it to melt and fuse the metal as per the requirement of the structure.

These technologies can 3D print only metal structures but can be used with a wide range of metals, in either wire or powder form. It is a faster and highly cost-effective process and can be used for printing colossal metallic structures. Precision is not a strength of this process and the surface finish is also lacking in finesse. Moreover, this method cannot create complex structures. Besides, this technology requires complex computer software for the build process and then post processing requires CNC machining, heat treatment and in some cases, surface polishing.

The most common applications of this technology involve effectively repairing high-end components, creating functional prototypes and final parts in industries as diverse as offshore oil and gas industries, aviation industries, power generation plants, utility industries, and so on.

Sheet Lamination: This technology is entirely different from all other 3D printing techniques. While all other processes can be thought of as "Bottom up", in which structures are created layer by layer beginning from the bottom, this process is "Top-down". Sheets of very thin material are stacked one upon another and then laminated. This stack is then shaped into the required object by cutting mechanically with a software-controlled laser beam. This is similar to monolithic structures being carved from a single rock to create statues.

Laminated Additive/Object Manufacturing (LAM/LOM), Ultrasonic Consolidation (UC), Viscous Lithography Manufacturing (VLM), Composite Based Additive Manufacturing (CBAM) and Selective Lamination Composite Object Manufacturing (SLCOM) are the various subtypes of this technology.

A wide variety of materials, like papers, polymers, metals, etc. can be used by this technology. These can be fused together by diverse media like glue, heat, laser, thermoplastics and even sound. The process is quite fast and cost effective and enables printing of composite articles using different materials. The disadvantages of this technique are that it generates a large amount of waste and the articles printed do not have good dimensional accuracy. Thus, laminated object manufacturing is largely used for rapid prototyping, as opposed to production. Since designers can quickly create a scale model with this type of 3D printing, they often use it to present new concepts to investors, customers and clients.

Some 3D printed articles

India's first 3D-printed post office located in Bengaluru's Cambridge Layout. (Express photo *by Jithendra M*)

Recently, as per a report in the 20 August 2023 issue of *The Indian Express*, India's first 3D-printed post office was inaugurated in Bengaluru. It was built in a short time span of just 43 days. The post office covers a built-up area of 1,021 sq ft. Its construction was carried out using 3D concrete printing technology, which is a fully automated building construction technology wherein a robotic printer deposits the concrete layer by layer as per the approved design. Special grade concrete — which hardens quickly — is used to ensure bonding between the layers for the purpose of printing the structure.

Visual schematic of a soft wearable glove for remotely monitoring stroke rehabilitation *(Image: Mesoscopic Lab, Department of Physics, IISc)*

Another report in an earlier issue of *Science Reporter,* "3D printed gloves for Rehabilitating Stroke Patients" (https://sciencereporter.niscpr.res.in/home/whatsnew), researchers in the Department of Physics at the Indian Institute of Science (IISc), Bengaluru, have developed a soft, wearable 3D printed device that utilises the fundamental properties of light to sense a physiotherapy patient's limb or finger movements. A silicon-based polymer material is used that can be 3D printed to fit the patient's arms and fingers. The customisable, 3D printed gloves can be remotely controlled, opening up the possibility of teleconsultation by physiotherapists.

Recognising the immense potential of 3D printing technology, the Government of India unveiled its National Strategy on Additive Manufacturing in February 2022. Its target is to add 5% to the global Additive Manufacturing market while aspiring to the ideologies of "Atmanirbhar Bharat" and "Make in India".

The technology is developing at a fast pace. People have already started using this technology at home, with small 3D printers, to print everyday gifting items, toys and items of home décor. A large number of user-friendly software are available free on the Internet aiding in manufacturing of objects from design to completion stage. With advances in electronics, nanotechnology and artificial intelligence, the growth in this field is sure to be incredible. The possibilities are endless.

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Cooking Metals the *Mysore Pak* Way!

Mysore Pak is enjoyed traditionally in the form of soft, perfect cuboids, but can you add some extra ingredients to spruce it up or 3D print it in customised shapes?

A Durga

OF the many joys of life, the mighty *Mysore Pak* surely holds a special place for many hailing from the south of India. When cooked and set to perfection, this dessert is soft yet not fudgy, sweet yet not simply sugary, and melts not like a chocolate but slowly, allowing one to taste every crumbling granule to its fullest.

When cooking metals and minerals too, we strive for that perfect texture, with atoms settled into their comfort zone, so that they may be used to make knives for cutting that *Mysore Pak* into perfect cuboids or even sharpening that knife! But can we use our cooking skills to solve metallurgical problems or the other way round?

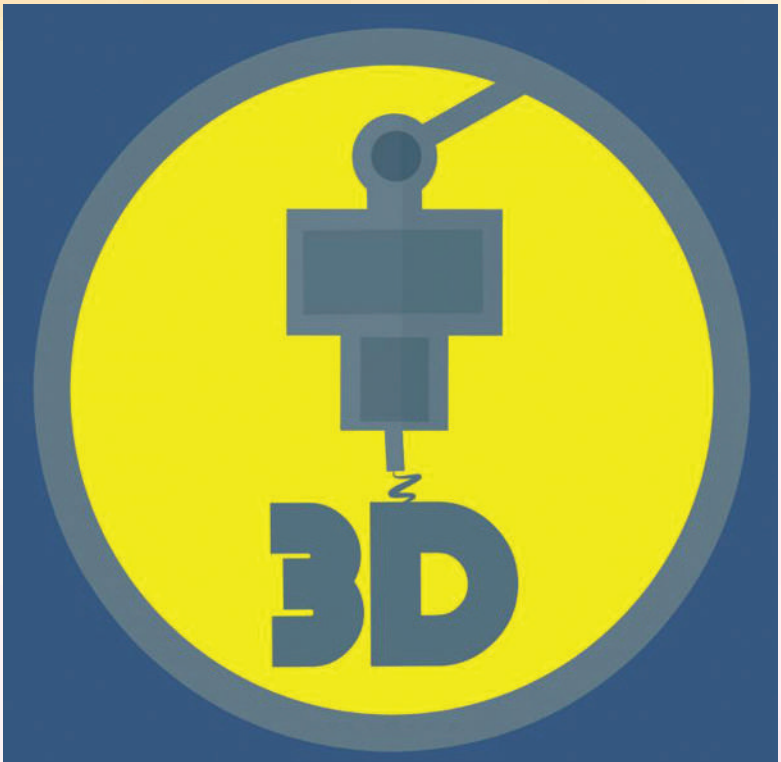

Image Credit: stockvault

My journey, both of cooking food and cooking metals, began over a decade ago. In the early days of my cooking on a cooking plate when I moved to Europe, I struggled to cook even the basic staple dishes I was used to eating back home in India, where cooking usually happens on a gas stove. And then I attempted the mighty *Mysore Pak*. I ended up, not with soft, perfect cuboids, but a porous, crumbling mass that could not hold any shape.

Fast forward to about five years ago. There were whispers of '3D Printing' technology with the potential to revolutionise manufacturing of metallic products. With 3D Printing, we could simply 'print' any 3D object that we want, without the need of any further operation like cutting or sculpting to create the right shape.

I started working on a project myself, to understand what the metallic alloys go through when put through this process and why many objects produced by 3D printing cracked. It was a familiar feeling — our same, beloved metallic alloys behaved very differently when put through this new process.

Six months after that disastrous first attempt, and with more experience in the meantime of cooking the basic dishes, I found the courage to make *Mysore Pak* again. I let the sugar syrup boil, not at the maximum heat, but in medium heat. I added the chickpea flour and lowered it to low-medium heat and maintained it at that level till the very end, when the clarified butter started separating. I poured the mixture in a tray and let it set.

We 3D Printing researchers have been attempting to optimise the process and the materials used in order to obtain crack-free printed parts. Can we change the temperature settings to obtain the perfect texture? Can we add some extra ingredients to strengthen the material and prevent it from cracking? These are the questions we address through our research.

Let us take a look into what would have happened to that *Mysore Pak* we left in the tray to set. *Mysore Pak* and 3D Printing using laser-based methods both start with powder: chickpea flour and metallic powder, respectively. In the former, we put it in sugar syrup and let it amalgamate. In the latter, one layer of metallic powder at a time is heated up with a laser and melted into a liquid. The *Mysore Pak* is allowed to form by pouring the liquid mixture into a tray for it to cool down into a solid block. The 3D printed part forms by the liquid metal cooling down into a solid block of the desired shape at each layer. The portions of the *Mysore Pak* liquid mixture closest to the bottom of the tray and the side-walls start cooling first and forming into a solid.

Similarly, the liquid metal in contact with the material below starts to cool and form a solid first. The *Mysore Pak* could not solidify uniformly as a block when first cooked using the cooking plate since the temperature of the liquid mixture was too high and it cooled rapidly. The liquid metal too undergoes rapid cooling rates and the solid does not form as a continuous network, but gaps are created, leading to cracks. If the solid forms more uniformly from the liquid, the resulting structure is much more resistant to cracking. Therefore, by controlling the temperature settings, the *Mysore Pak* we left in the tray did form perfectly and could be cut into soft, perfect cuboids. In 3D Printing too, cracks are prevented from forming by controlling the temperature settings.

However, this strategy does not work for all dishes or objects. Sometimes, it is that pinch of saffron that is required to give a dish its identity. Similarly, we may have to add some extra ingredients to the metallic alloys to strengthen them and give them the right texture. This line of research too has unearthed some new ingredients to add to the metallic alloys to 3D print them.

Cooking metals, like cooking food, has been more art than science historically, but with the understanding of how metallic atoms come together and behave during the process, the quality and efficiency of production of different products can be improved significantly.

I derive inspiration from my cooking to perform research on metals and 3D printing. Does something inspire you to also cook better from learning about metals and alloys? *Mysore Pak* is enjoyed traditionally in the form of soft, perfect cuboids, but can you add some extra ingredients to spruce it up or 3D print it in customised shapes?

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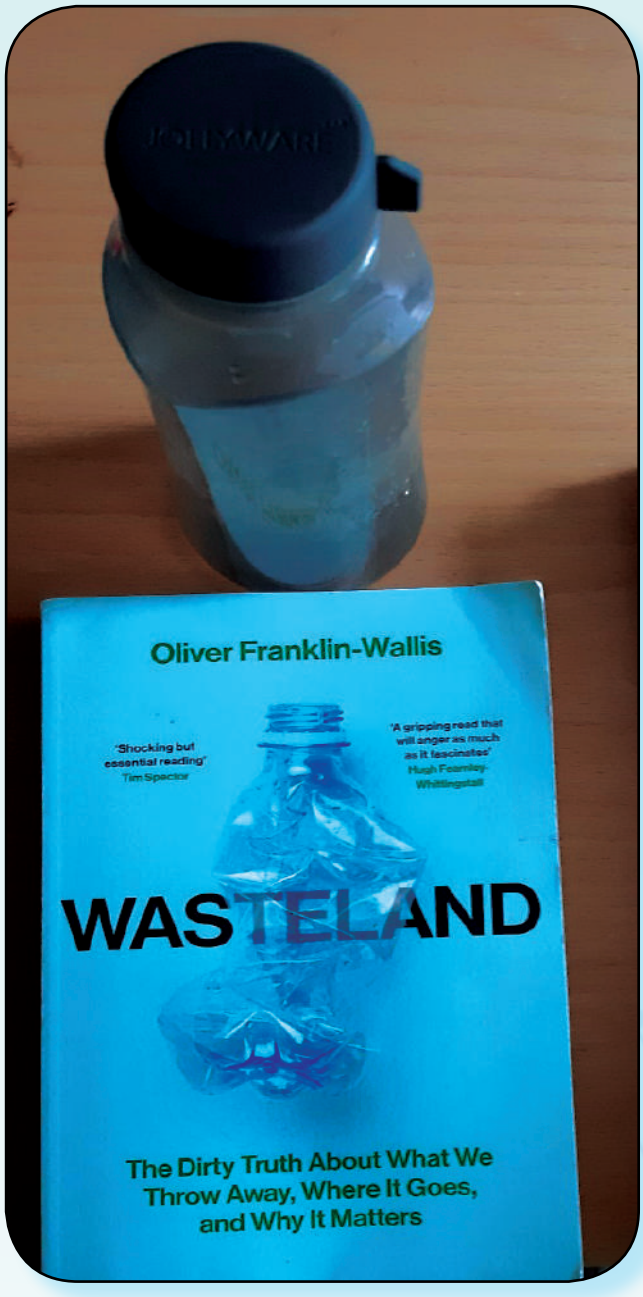
To spurn, burn or return...that is the concern

G Venkatesh



That concern is sure to stump a modern-day Hamlet, as readers will agree after reading Oliver Franklin-Wallis' Wasteland. A conundrumical concern more intriguing and vexing than the existential 'To be or not to be,' which Shakespeare 'dumped' into Hamlet's mind...

SHOCKING, essential, gripping, fascinating, enraging, engaging, interesting, urgent, probing, compelling, smart, fair, funny, very important....these are few of the adjectives used to describe Oliver Franklin-Wallis' *Wasteland* — a 390-page eye-opener of a book published by Simon and Schuster (UK) in 2023. I would add 'timely' to the mix, and replace the 'but' in the 'Shocking but compelling reading' (Tim Spector on the cover), with 'and therefore'.

The 'What', 'Where' and the 'Why' of waste generation and handling (or mishandling, rather) have been explained by the author with the skill of a raconteur, with the aid of the 'Who', 'When', and 'How' in this comprehensive account which is sure to interest professionals, decision-makers in government and industry, and most of all, students in universities around the world. It is this last-named group of potential readers to whom I would like to strongly recommend this book.

Oliver takes readers on a roller-coaster ride through Dirtiness (Part I), Foulness (Part II), and Toxicity (Part III), encompassing the multiple R's of a circular economy in the process, before finally leaving behind some good advice and hope for the future...

Introducing waste-exports as 'toxic colonialism' indulged in by a NIMBY (Not In My BackYard) western world, Oliver

acknowledges that where there is muck, there is brass, and quotes UK-based materials recovery facility Green Recycling's GM Jamie, to impress upon readers that it is often a matter of perspective — *We do not call it waste. We call it materials*.

And then, he leads you to the Indian capital city and the Ghazipur dump on its outskirts, and using words skillfully, enables you to visualise and imagine. Well, just as some Indians may have blamed Daniel Boyle and his crew for vividly portraying the poverty in Mumbai's slums in *Slum Dog Millionaire* and bagging eight Oscars in the process, readers of this book in India may wonder why Oliver Franklin-Wallis waxes eloquent about the Ghazipur dump. Well, the answer is to open eyes, ears and minds to a challenge that has been looming large for a long time, and needs urgent redressal...but then, is that feasible? It is a known fact that the ragpickers (or 'rag and bone men' as they were called in England in the 1800s) — marginalised citizens in modern urban societies — have been enduring a host of professional hazards all at once — chemical, biological, microbiological, physical, and psychological (https://www.ceeol.com/search/article-detail?id=1128402).

Spurned — Dumps to Landfills

The distinction is important here. Dumps refer to what is created by the process of open dumping like Ghazipur and Deonar (in Mumbai) referred to by the author. Wastes have open channels, so to say, to the atmosphere, hydrosphere and the pedosphere. Landfills however, are covered, and the wastes are not visible to passers-by. Sanitary landfills are engineered sequestrations of waste, with leachate and biogas collection in place, to curb ground water, soil and air pollution...and of course, to redesign the much-maligned landfills as 'energy plants'.

Oliver brings out the stark differences between Ghazipur and the Ellington sanitary landfill in the UK, while paying homage to the Californian Jean Vincenz, who can be conferred with the epithet, 'father of (official) sanitary landfills'. Better than dumps, yes, but yet, a squandering of resources — or materials as Jamie of *Green Recycling* would like to say. The author wonders what would happen to the livelihoods of the waste-pickers in the developing countries, if all dumps disappeared, and waste management became privatised, mechanised and automated. Decision-makers (urban planners) in these countries would rather like to push this concern under the carpet...far easier to see the dumps and the rodents scurrying up and down, than confront this seemingly unresolvable impasse.

The author makes readers pause and think when he quotes Anwar, the waste-picker/waste trader in Delhi — *I do not see waste. I see resources for myself*. Echoing the very same sentiments as the white-collar professional Jamie in another continent. The author infuses enthusiasm by quoting Vic who works at the Ellington sanitary landfill — *I feel that I have a responsibility to do this*. Yes, the world needs more people like Vic!

Delhi also attracts attention for the wrong reasons when it comes to dumping toxic wastes into rivers like the Yamuna. It is ironical (and hypocritical) that Hindus worship rivers as goddesses but have struggled to understand their carrying capacities (or assimilation limits). There is hope, the author points out, thanks to new clean-up schemes which have been put in place...but then religiously implementing them is what will matter in the long run.

While dumps and landfills are of course to be minimised and ultimately avoided in the future, Oliver points out more than once that dumped wastes have helped anthropologists to understand the past of human civilisation. Deriving value (knowledge, in this case) from wastes, in a different way! And Victor Hugo labelled the sewer as the conscience of the city, in *Les Miserables*. Continuing with the French, we learn that the English word 'loo' is actually sourced from *l'eau* which simply means 'the water'!

Dumps include tailings and slag heaps (mining wastes — unprocessed ore, rock and dirt) as well as radioactive waste from nuclear reactors, which potentially are human and environmental hazards. The author presents an overview of the toxic wastes generated by the mining sector globally, with some striking instances from Brazil; and also refers to the recycling of mining wastes into asphalt in the USA (as part of the implementation of the Comprehensive Environmental Response, Compensation and Liability Act).

It is sad but not surprising to read that the USA buried (landfilled and not composted) or burned (mostly without any energy recovery) 80% of its food waste in 2018. UK, the author's home country, fared much better in this regard, though he prefers not to use the USA as the 'benchmark of how not to be' and rejoice.

Burned — get rid of, and get energy

The description of the incinerator reminds one of Dante's Inferno (also referred to, by Oliver) — all types of wastes being purged together in the same fire. He does delve deep into the technology of incineration, and the problem-shifting which has to be avoided — the substances in the solid wastes which are to be gotten rid of, being partitioned into pollutants in the exhaust gas and bottom/fly ashes with a certain degree of toxicity. A responsible Energy-from-Waste, EfW (or Waste-to-Energy, WtE) plant, Oliver notes, has to treat the exhaust gases, and also arrange for the ashes to be either sequestered in sanitary landfills or recycled as additives in concrete.

The wastes which are incinerated include plastics (which trace their origin to crude oil) and the energy produced by the WtE plants, has a sizable greenhouse gas footprint — in per unit energy output terms. If recycling greater quantities of plastics is not possible or feasible, incinerating them for energy seems to be the next best option. It must be noted that all 'burning' is not accompanied by energy recovery. That is a cruel, unpardonable loss of resources — both materials and the energy-content thereof.

'Värde' means 'value' in Swedish. Waste has been rechristened as value. Here, they are being trucked to an incinerator to be burnt for 'clean' energy recovery. Picture by *G Venkatesh*, taken in Karlstad (Sweden), on 21 August 2023.

Returned — the virtuous R's in a circular economy

There are many virtuous R's associated with returning materials (not 'wastes'; remember Jamie!) or resources (not 'wastes'; remember Anwar) back to the anthroposphere — Recycle, Recover, Repurpose, Remanufacture, Refurbish, Repair, Reuse...To incorporate more of these into waste management, one needs to step out of one's comfort zone, rack one's brains, think out of the box and be creative, walk or jog the extra mile, and be determined to be the change one wishes to see around her/him/them.

The author exemplifies this by referring to jackets resewn as backpacks (repurposed or upcycled in the process), and discarded denim converted to agricultural protective gear in Accra by a company named The Revival. Often, one does these things by compulsion...and that is very common in a country like India, for instance. But choosing to do any or all of these in the affluent western world, is far from easy. Till you get introduced to the dumpster-diner/diver 'freegan' John in the UK, who eats edible food waste that others throw away, distributes some of it to homeless charities and composts the remaining, in a spiritual rejection of consumerism.

Up to a third of all the food produced in the world is thrown away, without being eaten — a gargantuan human and environmental tragedy, in the author's words. Composting, which John the freegan takes delight in, is recommended incidentally by Karl Marx in *Das Kapital!* Industrial-scale composting is now a century old, having originated in Italy during the first World War. Oliver names trendsetter South Korea, calling it the '*nirvana* for compost nerds', and writes that over 95% of food waste there is converted into compost and biogas. He however points out that it is not 'done and dusted' or rather 'done and composted', as microplastics and toxic constituents often render the compost unsuitable.

The author points out that though recycling as a public good is quite commonplace these days, there are 'dirty truths about where what we throw away goes'. And what he finds out and reveals, is indeed shocking, and readers will feel that the wool has long been pulled over their eyes. In a nutshell, a significant proportion of what is returned, say to the global second-hand 'repair-repurpose-resale for reuse' market, ends up being 'spurned' or 'burned'.

As an example, Oliver points out that 40 percent of the resold/resalable garments that flood into what is the largest second-hand market in Ghana — 'complete chaff' in the words of the head of Accra's waste management department — ends up in a subterranean dump which pollutes surface rivers and groundwater. Shipped in (as part of charity) to be resold and reused, but ending up getting 'dumped by the westerner' as a part of modern-day neo-colonialism. It is this proportion which needs to be decreased consciously (and conscientiously) over time. Ghana incidentally also takes in a lot of electronic waste from the western world and the beautiful nexus that

prevails between the repair-reuse culture in the country and the scrap recyclers, recirculates electronic waste back into the anthroposphere, refurbished and reusable. To quote Evans Queye, an e-waste recycler in Accra, *'Recycling, one way or the other, creates some environmental impacts...but these are much less than what is created by processing raw materials.'*

It is interesting to read about how the imports of scrap metal contributed to China's monumental economic growth, and how wastepaper recycling was behind the emergence of the first Chinese woman billionaire (Zhang Yin of *Nine Dragons*).

Plastics (and thereby microplastics) have attracted a lot of attention of late. Oliver creates an epiphany — at least it was one for this reviewer — when he writes that plastics themselves are sourced from wastes (or byproducts) generated in oil-refineries which have fossil fuels as their primary products. Polyethylene Terephthalate or PET is a ubiquitous plastic waste, potentially recyclable to a great extent (a finite number of times, with loss in quality in the process), but being subjected to incineration and landfilling quite widely. '*Absolute bollocks...greenwashing,*' as Chris Hanlon of Biffa Polymers (UK) tells the author, '*most plastic bags and films which are returned for recycling are sent away somewhere to be burned or buried.*' A reference is made to chemical recycling which can potentially handle a wider variety of plastics in the future. However, can those plastics which are difficult to recycle be gradually phased out?

While wastewater treatment plants have evolved over the years to 'refineries extracting value out of human wastes', Oliver refers jokingly to the fact that arms manufacturers in England in the 17th century considered excrement as the raw material for potassium nitrate production, and that 'the Spanish Armada was defeated, at least in part with Londoners' shit'.

He writes about the existence of water cascading (the need of the 21st century) in ancient Rome, and the respect accorded to the sewers by adding a goddess Cloacina to the pantheon (*cloaca* means sewer), Joseph Bazalgette and his redesigning of the sewer system in London to 'take shit out of the public eye', and leaves readers to chuckle at *'Shit still happened, but in private'*. But yes, on date, sewage is not returned for valorisation to wastewater treatment plants all over the world, and that is common knowledge. In cases where it is returned, in the words of Dina Gillespie, the site manager at London's Mogden sewage treatment plant, Oliver interacted with, *'The general public just flush the toilet and nobody really knows what we are doing. If we did not do what we do, there would be big problems.'*

This is where history is useful — the knowledge of the cholera outbreaks of yore will instil a great degree of appreciation and gratitude for the work done by the personnel at sewage treatment plants in the cities of the world. Sewers, Oliver remarks, are perhaps the greatest contribution of the Victorian Era to the modern world — ranking above railways, bridges and steam ships.

Wonder, ponder....

Well, instead of having to spurn, burn or return, perhaps, deciding not to buy stuff one does not need, will be the best way to show concern in the years ahead. Planned obsolescence practised by the industry (and explained in detail by the author in the chapter *Control, Delete* in part III) must be recognised as something evil.

This will also stanch the import of second-hand goods into the developing world, and perhaps allay the socio-economic and environmental challenges faced therein. More and more second-hand shops can very well be set up in the developed world as well, so that a domestic market burgeons at the expense of an export market. Many such small decisions will amount to a groundswell of much-needed change. Nevertheless, there are many 'known and unknown unknowns' here — ripple effects, both desirable and otherwise — which make analyses, decision-making and judgment quite complex. What about the livelihoods of the poor people in the developing countries who depend upon such imports?

The book, when read from cover to cover, is likely to not just make readers wonder and ponder, but also motivate them to not blunder and squander. *Wasteland,* as the reviewer indicated early on, has been published just at the right time, when it is most needed! Spending money on a copy will surely be an investment with good returns...not a waste.

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CSIR-CIMFR Celebrates "One Week, One Lab"

CSIR-Central Institute of Mining and Fuel Research (CSIR-CIMFR), Dhanbad, celebrated the "One Week, One Lab" Campaign from 22 to 26 August 2023. The opening ceremony of the campaign was held at Hotel Radisson Blu in Ranchi on 22 August 2023.

Dr N Kalaiselvi was the Chief Guest and the event was attended by more than 300 participants comprising experts from various mining and fuel industries, academic institutes, officials from local administration and scientists and staff from CSIR-CIMFR. A technology was transferred and seven MoUs were signed on the occasion.

The Yuwa Manthan i.e Young Researchers Conclave programme was held at Digwadih campus of CSIR-CIMFR on 23 August 2023 where research papers were presented by young scientists, research scholars and invited speakers through lectures and posters.

On 24 August 2023, the Vidyarthi-Jigyasa i.e. Open Day programme was successfully conducted to engage school children from Dhanbad and its neighbouring areas. The goal was to captivate young minds by showcasing the practical applications of science in national development. This programme was executed across multiple venues, including the Barwa Road and Digwadih campuses, as well as all regional centres situated in Nagpur, Bilaspur, Roorkee, and Ranchi. More than 1000 students from various schools participated. Exhibitions by school students and also technologies from CSIR-CIMFR were showcased during the occasion.

The Gyanodaya (Thematic Lectures) programme focusing on the theme "Mining for Sustainable Development and Energy for Growth of the Nation" was hosted on 25 August 2023 at CIMFR Barwa Road campus. Distinguished luminaries from various industries, academic institutions delivered plenary speeches.

On the last day 26 August 2023, the Udaan (Startup Meet) and Udyog Sangam (Industry Meet) under the theme of "Transformative Research for Industrial Excellence," were organised to facilitate fresh partnerships, promote inventive resolutions, and enhance the relationship between the scientific community and industrial sector.

Finally, the Closing Ceremony was organised on the same day, which was graced by Shri Prabhat Kumar, DG, Directorate General of Mines Safety. The event was followed by a Cultural Programme.

CSIR-NIScPR's "One Week, One Lab" — Engaging Science & Society

Joining the "One Week, One Lab" campaign of CSIR, CSIR-National Institute of Science Communication and Policy Research (CSIR-NIScPR), New Delhi, organised the weeklong programme from 11 to 16 September 2023.

During the programme, the institute hosted a series of events creating a science-festive atmosphere all around highlighting and showcasing the institute's activities, initiatives and achievements in the areas of Science Policy Research and Science Communication. The events catered to a wide range of audiences including scientists, academicians, science diplomats, scientists, science communicators, science publishers, entrepreneurs, industry experts, farmers, startups, students and other stakeholders.

The programme was kicked off with the curtain raiser event on 6 September 2023 held at PHD Chamber of Commerce, New Delhi. Dr Rakesh Bhatnagar, National Science Chair at Jawaharlal Nehru University was the Chief Guest of the event and other dignitaries included Dr Souvik Maiti, Director, CSIR-IGIB and Dr Manoranjan Parida, Director, CSIR-CRRI. Director, CSIR-NIScPR, Prof. Ranjana Aggarwal briefed about the "One Week, One Lab" programme as well as the NIScPR activities.

Dignitaries also released NIScPR's One Week, One Lab brochure, a short film featuring the activities of the institute was also shown.

Dr Jitendra Singh, Hon'ble S&T Minister delivering his address during the inauguration

The weeklong programme was inaugurated on 11 September 2023 by Hon'ble S&T Minister Dr Jitendra Singh. Dr N Kalaiselvi, Secretary, DSIR and DG, CSIR, was the Guest of Honour; Prof. Venu Gopal Achanta, Director, CSIR-NPL was the Special Invitee. Following the inaugural ceremony, the names of the twelve Shanti Swarup Bhatnagar (SSB) awardees for the year 2022 were also announced.

Appreciating the institute's activities Dr Jitendra Singh said, "CSIR-NIScPR has shown the unique capacity of dissemination of scientific achievements to the society. People have started realising the significance of the core strength of this Institute." The minister further emphasised that the experiments conducted within the walls of the labs must reach out to the stakeholders. Dr Singh expressed his appreciation for NIScPR's SVASTIK initiative, which combines traditional knowledge with modern scientific knowledge. He also congratulated the SSB awardees.

Addressing the gathering, Dr N Kalaiselvi emphasised the significance of science communication, saying that it serves as a bridge between scientists and the lay public. She praised science communicators as the real unsung heroes who play a crucial role in linking the gap between labs and the masses.

Prof. Venu Gopal Achanta said, "NIScPR is a binding force for all the CSIR labs as it records science history and disseminates it to the general public through publications."

Earlier, in her welcome address, Dr Ranjana Aggarwal praised the campaign as a unique platform for showcasing the technological breakthroughs and success stories of each CSIR lab to a diverse range of stakeholders. She credited the Hon'ble Minister Dr Jitendra Singh, for his visionary leadership and unwavering support in making this campaign a reality.

Marking the completion of 80 years of CSIR since its inception in 1942, a book, *"CSIR@80: A Photo Journey (1942-2022)"* was released by the Hon'ble Minister. A book "*Vigyan Pragati's Shreshtha 80 Alekhon Ka Sankalan*" in Hindi was also released. Hon'ble Minister also inaugurated the "Science Media Communication Cell (SMCC)," an initiative of CSIR-NIScPR that focuses on the dissemination of Indian R&D breakthroughs through effective media communication. After the inaugural session, an exhibition of CSIR-NIScPR knowledge products was opened to the general public.

The next day, on 12 September 2023, a workshop on "India's Startup Revolution — An Exciting Journey from an Idea to Market" was conducted at CSIR-NPL. The Chief Guest of the workshop was Dr Omkar Rai, Executive Chairman of Startup Odisha and the Guest of Honour was Mr Puneet Kaura, Chairman, CII Delhi State Council and Managing Director & CEO Samtel Avionics Ltd. The workshop aimed

Release of book

at exposing students to pathways towards converting their ideas into commercial products and providing a platform for networking. It was attended by industry players, startups, research institutes, universities, government bodies, and incubators involved in promoting startups.

Dr Omkar Rai spoke about India's efforts at helping startups grow in tier-2&3 cities. Mr Puneet Kaura stressed on building a growth mindset, continuous learning, networking and connecting with mentors, peers, and partners for scaling up and finding pathways to growth.

During the workshop, three books were released by the dignitaries, namely, *Tech Readiness: Evaluating CSIR Innovations Under Agricultural and Environmental Themes*; *AcSIR Academic Handbook for PhD Programme*, and *Synthesis Report: Study of Life Sciences Cluster in the Context of COVID-19*, *A Case Study of Genome Valley*.

The day-long startup workshop included technical and interactive sessions as well as panel discussions on different aspects of the startup ecosystem. The exhibition of over 30 startups, ranging from high technology to those impacting rural development, was one of the attractions. Industry experts and heads of incubation centres also discussed ways to enhance the startup ecosystem in the country.

On 13 September 2023, three programmes were conducted — Grassroot Innovations & Skill Development Conclave for Rural Development, Student-Science Connect Programme, and CSIR-NIScPR & KAMP Workshop for Teachers.

Grassroots Innovations and Skill Development Conclave for Rural Development began with the inauguration of an exhibition by Dr Shekhar C Mande, Former DG-CSIR, & Chief Guest of the event and Dr Sanjay Kumar, Chairman, Agricultural Scientists Recruitment Board (ASRB) was the Guest of Honour. The exhibition showcased technologies/ products from different CSIR labs such as CSIR-IHBT, CSIR-AMPRI, CSIR-IIP, CSIR-CIMAP, CSIR-CSMCRI, CSIR-NBRI, CSIR-NIIST, CSIR-IICT and CSIR-NIScPR.

Addressing the gathering, Prof. Ranjana Aggarwal emphasised the multidisciplinary nature of CSIR-NIScPR, which serves as a vital bridge between science and society at large.

Dr Sanjay Kumar stressed the importance of making scientific advancements accessible to the public and understanding stakeholder needs.

Dr Shekhar C Mande emphasised the importance of research and innovation in shaping the nation's future.

The programme on Student-Science Connect was attended by more than 150 students from Kendriya Vidyalaya Vikaspuri, Kendriya Vidyalaya Dwarka, and MM Public School. Shri CB Singh, Head, Jigyasa Training and HR Division, CSIR-NIScPR, gave an overview of the programme.

Prof. Ranjana Aggarwal emphasised the relevance of the two themes for the programme — millets and scientifically validated Indian traditional knowledge.

The programme was also graced by Dr Shekhar C Mande, Dr Sanjay Kumar and Prof. Sharmistha Banerjee, University of Hyderabad. Dr Mande highlighted the efforts undertaken by CSIR-NIScPR in the preservation and revitalisation of diminishing Indian Traditional Knowledge. He emphasised the significance of the NIScPR publication "*Wealth of India*" in this regard.

Dr Sanjay Kumar stressed the importance of learning through fun, teamwork, and building meaningful connections with extended family. Prof. Sharmistha Banerjee talked about India's contributions to the fields of Science and Technology. The annual report for Jigyasa, covering the period of 2022-2023, was also unveiled.

The programme included talks on the nutritional importance of millet, and scientific communication of traditional knowledge. A quiz competition and puppet show centred on science communication were also held. The event was concluded with a visit to the Raw Materials Herbarium & Museum and Ayur Vatika at CSIR-NIScPR.

The same day, a CSIR-NIScPR & KAMP Workshop on Science Communication was also organised to sensitise participating science teachers about the various facets of science communication.

Welcoming everyone, Shri CB Singh outlined the workshop's objectives. Following this, the audience was captivated by the keynote speech delivered by Prof. Sharmistha Banerjee from the University of Hyderabad.

The sharing of knowledge on an integrated approach in the education system by Prof. Sharmistha Banerjee opened the floor for insightful discussions. She emphasised the importance of introducing research and scientific methods at the school level, advocating for a more interdisciplinary approach to education.

Subsequently, in his lecture on "Science Communication: Indian Efforts and Citizen Responsibility," delivered by Shri Hasan Jawaid Khan, Chief Scientist and Head of Popular Science Division, CSIR-NIScPR, shed light on the challenges of information consumption in today's era of information overload. Finally, Ms Sonali Nagar, Senior Scientist, CSIR-NIScPR, addressed the audience on "Nuances of Popular Science Writing," focusing on the intricacies of scientific writing and highlighting the essential elements of effective communication.

On day four, 14 September 2023, the event on "Science Communication: Public Engagement with Science" was organised. The Chief Guest of the event was Dr Santosh Choubey, Chancellor, Rabindranath Tagore University, Bhopal, and the Guest of Honour was Dr Tsering Tashi, Deputy Project Director, Navigation Spacecraft, UR Rao Satellite Centre, Indian Space Research Organisation (ISRO), Bengaluru. The programme had a technical session, panel discussion and Vigyan Kavi Sammelan.

During the inaugural session, Dr Ranjana Aggarwal highlighted the significance of the science communication event and emphasised the importance of public engagement.

During the release

Shri Hasan Jawaid Khan, Chief Scientist, CSIR-NIScPR, provided a brief background of the event focussing on science communication and its key challenges.

Dr Tsering Tashi discussed his journey of scientific research at ISRO and stressed the importance of science outreach activities for rural communities and how he had helped numerous students from the Ladakh region through science communication programmes.

Interacting with the audience, Dr Santosh Choubey emphasised the significance of science communication and suggested creating science communication hubs across the country.

A book titled *Vigyan Sanchar Ki Anwarat Yatra;* three CSIR-NIScPR popular science books in English translated into Marathi, Kannada, and Bangla respectively; *Navasanchetana* CSIR-NIScPR *Rajbhasha* magazine (July-Sept 2023 issue), and an "*e-Hydrogen Digest Compendium*" based on hydrogen research were released.

Dr Manish Mohan Gore, Editor, *Vigyan Pragati,* who was responsible for conceptualising the day-long programme, delivered the vote of thanks.

After the inaugural, a technical session on "Organisations spreading science to society" was chaired by Dr Santosh Choubey and co-chaired by Dr Tsering Tashi. Experts from reputed organisations like Department of Science & Technology, All India Radio, National Research Development Corporation, TIFR, IGNOU, etc. participated.

Later, a panel discussion was held to mark the completion of 70 years of "*Vigyan Pragati*," the monthly Hindi magazine published by CSIR-NIScPR. The discussion was chaired by Shri Devendra Mewari, a renowned science writer, and co-chaired by Shri Kuldeep Dathwalia, Project Manager, Science Media Communication Cell (SMCC). Ms Shubhada Kapil, Assistant Editor, *Vigyan Pragati,* presented the milestones of the magazine's journey. This was followed by various speakers sharing their experiences of writing for *Vigyan Pragati* and how it had shaped their writing skills.

Commemorating the Hindi Diwas on 14 September, a Vigyan Kavi Sammelan was also organised during which Shri Mahendra Kumar Gupta, Joint Secretary, Administration, CSIR was the Chief Guest and the chairperson was Dr Madhu Pant, a renowned Science Poetess and former Director, Rashtriya Bal Bhawan, New Delhi. Poets from different organisations participated and made the evening eventful.

Shri Mahendra Gupta appreciating the efforts said that such kind of science-literature integration will definitely communicate science to society in the right way. Dr Ranjana Aggarwal expressed her gratitude to all the participating poets for their creative engagement. Dr Madhu Pant recited her science poem 'Dharati ki Yahi Pukar' which was commended by the audience.

On day five, 15 September 2023, the Science Knowledge Convention event was organised. It was inaugurated by Chief Guest Dr Akhilesh Gupta, Secretary, SERB and Senior Adviser at the Department of Science and Technology (DST) and Guest of Honour Dr Suman Kumari Mishra, Director, CSIR-CGCRI, Kolkata. The convention aimed to showcase e-resources, databases, standards and knowledge products for S&T staff, researchers, students and NKRC Nodal officers. It also featured signing of MoUs between CSIR & DST and CSIR & MoES for NKRC.

The "One Month One Lecture on e-resource" initiative was also launched along with the *NKRC Report: A Journey of 21 Years,* and special issues of CSIR-NIScPR journals *IJBB & IJEMS*. Subsequently, a panel discussion on Science and Technology Information and Knowledge Resources was held, which was chaired by Dr Manoranjan Mohanty, Head, Autonomous Institutions Division, DST and Mrs Neelu Srivastava, Chief Scientist, CSIR-NIScPR, as the Co-Chair.

Lastly, an Authors and Publishers Interaction Meet was held with sessions on scientific writing and publications, indexing tools, and e-resources for S&T research and databases. Dr Suman Mallik, former Chief Scientist, CSIR, was the Chair and Shri CB Singh, Sr Principal Scientist at CSIR-NIScPR was the Co-chair of the session. Two open sessions for discussion were organised.

A Science Exhibition and a Poster Presentation Competition were organised with the theme of Societal Impact of Research/Projects undertaken. Many students and guests participated, and several reputable science publishers including Wiley, Clarivate, Elsevier, and American Chemical Society (ACS) set up stalls. Dr Manoranjan Parida, Director of CSIR-CRRI, addressed the audience and distributed prizes to the poster competition winners. Over 800 participants attended both offline and online.

Dr Philipp Ackermann, German Ambassador to India and Bhutan, German Embassy while sharing his thoughts during the event

The weeklong programme concluded on 16 September 2023 with the event "Science Diplomacy for Sustainable Development" exploring how science diplomacy can contribute to sustainable development, sustainable entrepreneurship development in particular. The Chief Guest Dr Philipp Ackermann, German Ambassador to India and Bhutan, and Guest of Honour, Dr Bhaskar Balakrishnan, Former Science Diplomat, addressed the gathering. Dr Rama Swami Bansal, Head, International S&T Affairs Directorate, CSIR; Prof. Madhav Govind, Chairman, Centre for Studies in Science Policy, JNU; Shri R Madhav, Director, Indo-German S&T Centre; Dr Purnima Rupal, Former Director, CEFIPRA & Head, SCDD, CSIR and Dr Dhoya Snijders, Innovation Counsellor for India, Embassy of Kingdom of Netherlands attended the event as expert speakers.

Summarising the weeklong programme, Dr Yogesh Suman, Sr Principal Scientist & Chairman, NIScPR "One Week, One Lab" programme, presented the summary of the events. Concluding the programme, Dr Manish Mohan Gore, Scientist & Coordinator, NIScPR "One Week, One Lab" programme proposed the vote of thanks.

"One Week, One Lab" Event at CSIR-CMERI

The Curtain Raiser ceremony of the "One Week, One Lab" programme of CSIR-Central Mechanical Engineering Research Institute (CSIR-CMERI), Durgapur, was held on 21 August 2023 at CSIR-NPL, New Delhi, in the august presence of Dr Jitendra Singh, the Hon'ble Minister of Science and Technology & Vice-President of CSIR; Dr N Kalaiselvi, Secretary, DSIR & Director General, CSIR; Dr NC Murmu, Director, CSIR-CMERI; Prof. Venu Gopal Achanta, Director, CSIR-NPL and other dignitaries from various institutes, industries and other organisations.

The Hon'ble Minister launched and witnessed some of the nationally important technologies developed by CSIR-CMERI like E-Tractor, Vehicle Mounted Mechanised Drain Cleaning System (VM-MDCS), Mob Control Vehicles (MCV), Integrated Municipal Solid Waste Management Disposal System (iMSWDS), etc. CSIR-CMERI also transferred the technology of iMSWDS to three MSMEs from Bihar, Rajasthan and West Bengal for further commercialisation and deployment. The commercial version of VM-MDCS machine, developed by one of the licensees of CSIR-CMERI, was demonstrated in front of the Hon'ble Minister and other dignitaries present in the event.

The institute inaugurated its "One Week, One Lab" programme on 11 September 2023 to showcase the legacy, exclusive innovations, and technological breakthroughs achieved by the Institute.

The first day was celebrated as the "Farmers Connect event". More than sixty farmers from the adjoining districts of Durgapur were present in the inaugural event along with officials from the Department of Agriculture, Govt of West Bengal. The officials deliberated on different governmental schemes currently available to the farmers and also urged CSIR-CMERI scientists to work towards solving different technological issues being faced by the farmers and Indian agriculture as a whole. Later, various agricultural machinery developed by CSIR-CMERI were demonstrated to the farmers.

An interactive session on *Pradhan Mantri Mudra Yojana* and various schemes/loans available from nationalised banks for the farmers' community was also organised for the farmers with experts from Krishi Vigyan Kendra (KVK), Ministry of MSME and UCO Bank.

Second day on 12 September 2023, the Make in India and MSME Connect event was held in which representatives from MSME, startup companies, and individual innovators including student innovators participated. The event was graced with the presence of Dr NC Murmu; Dr Sujata Chaklanobis, Scientist G & Head, CRTDH (Common Research & Technology Development Hub), DSIR; Dr NP

Sinha, Mentor of Centre for Education & Training, Indian Institute of Foundrymen as the Guest of Honour; and Prof. Indranil Manna, Vice Chancellor, BIT Mesra, Ranchi and Former Director, IIT Kanpur and CSIR-CGCRI as the Chief Guest.

Dr Chaklanobis deliberated on the functioning of the CRTDHs established across the country analogous to the formation of a Golden Triangle between the Government, Industries (including MSME) and Academia (including the R&D organisations). A *Chintan Shivir* and a *Samvad* were organised with the DSIR officials on the panel for one-to-one interaction with MSME representatives on the challenges faced by them.

Robotics and Automation event was organised on 13 September 2023 during which Shri Brijendra Pratap Singh, Director-in-Charge, Burnpur and Durgapur Steel Plant was the Chief Guest and Shri Aditya Kumar Sinha, Center Director, Center for Development and Advanced Computing (C-DAC), Kolkata and Patna was the Guest of Honour.

Dr NC Murmu highlighted various R&D achievements of CSIR-CMERI in the recent past specifically focusing on development in the domain of robotics spanning robotic systems for interventions in the power sector, mining, social and strategic sectors, Autonomous Underwater Vehicles (AUVs) for oceanic applications and flexible actuation systems for human-friendly applications.

Shri Sinha expressed that CDAC is keenly interested in close work with CSIR-CMERI in potential fields of Agricultural Research, Robotics & Automation.

Subsequently, Shri Singh, the Chief Guest mentioned that the "Robotics & Automation" theme of the programme has great significance in the industry context, especially in Industry 4.0.

During the day-long programme, several startups/ Industry/Government Sectors participated and presented their credentials and needs where CSIR-CMERI can cooperate and collaborate. Commodore Amit Ray, Indian Navy, delivered an expert talk on "Time for Autonomous Underwater Vehicles". Commodore Ray lauded CSIR-CMERI's contributions to the Underwater Robotics domain.

Day four, on 14 September 2023, the Clean and Green India event was organised. Dr NC Murmu in his welcome speech, talked about the significance of "Clean and Green India" and the pivotal role that CSIR-CMERI plays in advancing this noble cause. CSIR-CMERI developed the "Integrated Municipal Solid Waste Disposal System", which is a first-of-its-kind infrastructure located at CMERI residential colony campus right in the heart of the city, was demonstrated to the dignitaries and representatives from various Municipal Corporations, Zilla Parishad and Panchayat Samiti of West Bengal.

Mr Prabhat Kumar Singh, the Managing Director of the National Safai Karamchari's Finance & Development Corporation (NSKFDC) graced the occasion. CSIR-CMERI has also transferred two modules of the technology for *i*-MSWDS to M/s Akash Enterprise, North 24 Parganas.

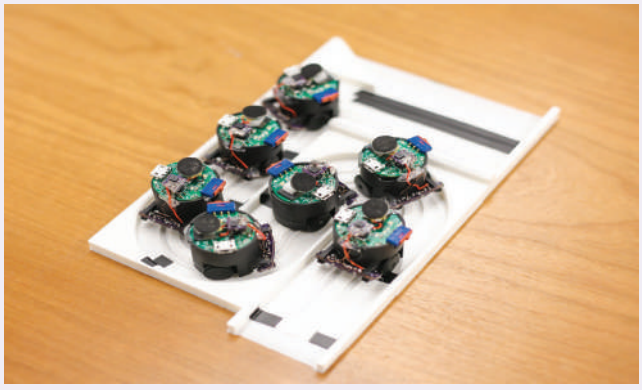
CSIR-CMERI scientists presented their "Strategic Research Approach towards Green India" in a number of ways, like solar photovoltaic generation and installation of a micro-grid at Sundarban area, cutting-edge energy storage technologies, from the remarkable graphene ultra-capacitor to aqueous batteries and compressed hydrogen storage tanks. The third line of research activities is in the domain of Electric Vehicle (EV) technologies tailored for agricultural applications. Their recent achievement, the indigenous E-tractor, stood as a testament to their ingenuity.

The fifth and final day of the programme was celebrated as the Jigyasa and Student Connect event on 15 September 2023. Twenty nine teams consisting of around one hundred students of sixteen schools participated in the Science Model Competition organised on the theme Save Earth.

Dr Debiprosad Duari, Former Director, Research & Academics, MP Birla Institute of Fundamental Research & Institute of Astronomy Space and Earth Science, Kolkata, was the Chief Guest of the event. Dr Duari in his inimitable style mesmerised all present in the auditorium through a popular science lecture on "A Cosmic Voyage".

A "Jigyasa Rath" displaying the technologies developed by CSIR-CMERI started its journey on the day to reach the school students to make them aware of the latest developments in science & technology and to develop scientific temper in the young minds. The scientists and technical officials of CSIR-CMERI interacted with 3350 students and 112 teachers of the above schools and were overwhelmed by the interest and scientific curiosity expressed by the students, the future hope of the country.

Shape-changing smart speaker lets users mute different areas of a room

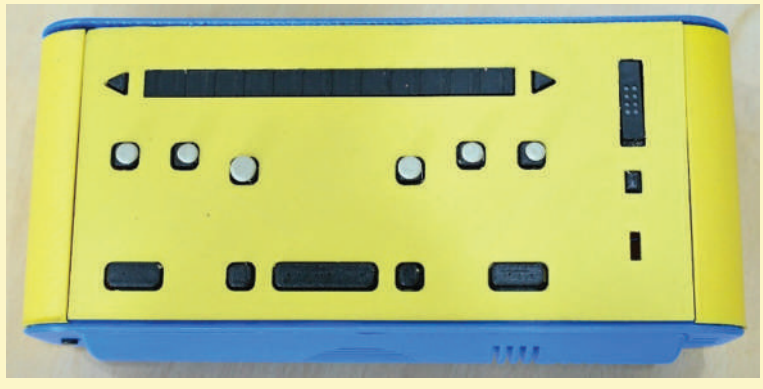


A team led by researchers at the University of Washington has developed a shape-changing smart speaker, which uses self-deploying microphones to divide rooms into speech zones and track the positions of individual speakers. The findings are published in *Nature Communications*.

With the help of the team's deep-learning algorithms, the system lets users mute certain areas or separate simultaneous conversations, even if two adjacent people have similar voices. Like a fleet of Roombas, each about an inch in diameter, the microphones automatically deploy from, and then return to, a charging station. This allows the system to be moved between environments and set up automatically. In a conference room meeting, for instance, such a system might be deployed instead of a central microphone, allowing better control of in-room audio.

Source: University of Washington, Press Release

Novel touch-sensitive Braille learning device for the blind and visually impaired



RESEARCHERS from IIT Kanpur, developed the "Single Refreshable Braille Cell Based Braille Learning Device with a Touch Sensitive Array" to make a significant impact in the field of accessible education. The affordable, self-learning solution has the potential to transform the lives of countless visually impaired individuals.

A Single Refreshable Braille Cell usually converts electronic text into Braille characters that can be read by touch. The existing devices in the market normally use multiple braille cells to get the required functionality. But, in the pioneering technology developed at IIT Kanpur, a single braille cell has been seamlessly integrated with a cutting-edge touch array, enabling the device to deliver functionality comparable to multi-cell counterparts but at a significantly reduced cost. The device is specifically designed to instruct users in the fundamentals of braille, covering basic characters, words, and sentences.

Source: IIT Kanpur, Press Release

Researchers achieve near-perfect light absorption in atomic-scale material

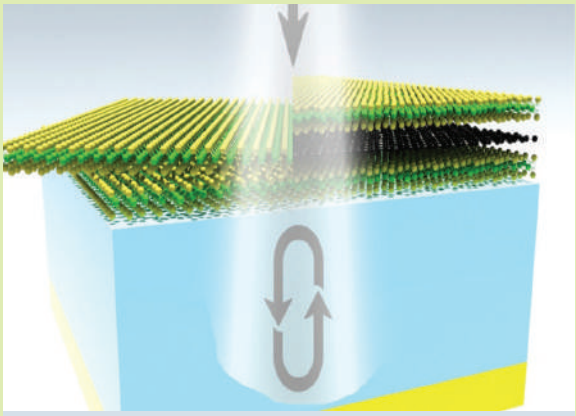


Photo credit: Steve Koester, University of Minnesota

A University of Minnesota-led team has engineered an atomically thin material that can absorb nearly 100% of light at room temperature, a discovery that could improve a wide range of applications from optical communications to stealth technology. The paper is published in *Nature Communications*.

Materials that absorb nearly all of the incident light — meaning not a lot of light passes through or reflects off of them — are valuable for applications that involve detecting or controlling light.

The researchers made this "near-perfect absorber" possible by using a technique called band nesting to manipulate the already unique electrical properties in a material made up of only two to three layers of atoms. Their fabrication method is simple, low-cost and requires no nano-patterning methods, which means it's easier to scale up than that of other light-absorbing materials being studied.

Source: University of Minnesota, News Release

IIT Madras Launches 'MovingMemory' App

INDIAN Institute of Technology Madras (IIT Madras) Centre for Memory Studies has launched a 'MovingMemory' app that uses the technology of Augmented Reality and Virtual Reality simultaneously. It captures various moving models of memory through digital reconstruction. It is a spatial app, developed with the potential to inhabit the metaverse world.

The functions of the app enable the user to select any desired avatar and navigate through three-dimensional spaces. It is embedded with additional layers of video, audio, 3D images, and interactive elements which may be used as models for sustainable and heritage-oriented pedagogic and research approaches. It can be accessed either through mobile apps (Android and iOS) or through browser-based platforms, making it uniquely inclusive in quality.

Source: IIT Madras, Press Release

TEST YOUR KNOWLEDGE

PLASTIC IN OUR DIET

Bibhuti Narayan Biswal

1. **The Global Partnership on Marine Litter (GPML) reports shows the majority of humans bear traces of plastic in their body. How do plastic particles enter the human body?**
   a) Through breathing contaminated air
   b) Through direct skin contact with plastic
   c) By consuming plastic-contaminated food and water
   d) By standing near plastic waste

2. **The report of Ocean Defenders Alliance (ODA) indicates huge plastic pollution in marine ecosystems. What is the primary source of plastic ingestion in marine animals?**
   a) Plastic bottles
   b) Plastic bags
   c) Plastic straws
   d) Microplastics

3. **Animals, especially humans, ingest thousands of microplastics (small plastics less than 5 million microns) per day in various ways like water, salt, and shellfish. In a week we eat microplastics equivalent to a credit card weighing around...**
   a) 5 grams
   b) 7 grams
   c) 10 grams
   d) 9 grams

4. **Around the world, the largest source of plastic ingestion is drinking water. The water that contains the maximum number of plastic fiber is...**
   a) River water
   b) Groundwater
   c) Water from the lake
   d) Bottled water

5. **How do microplastics enter the water supply which is primarily responsible for plastic ingestion in humans?**
   a) Microplastics are generated from water evaporation
   b) Runoff from plastic-contaminated landfills and water bodies
   c) Fish excrete microplastics into the water
   d) Volcanic eruptions release microplastics

6. **Which of the following daily used food items is most vulnerable to plastic contamination?**
   a) Frozen seafood
   b) Canned soups and sauces
   c) Whole grains and legumes
   d) Fresh fruits and vegetables

7. **How do microplastics from the plastic packaging industry enter our food chain?**
   a) Microplastics are released from food containers during cooking
   b) Microplastics contaminate water is used for food production and supply
   c) Microplastics are directly added to our food to preserv it
   d) Microplastics are produced naturally in some food items

8. **According to a Plastic-Free Society study, which type of plastic is most commonly found in the human diet?**
   a) Polyethylene (PE)
   b) Polyvinyl Chloride (PVC)
   c) Polystyrene (PS)
   d) Polyethylene Terephthalate (PET)

9. **The amount of microplastics humans ingest in their entire lifetime is very high. It is estimated to be the weight of two large recycling dustbins and is equivalent to**
   a) 18 kg b) 12 kg
   c) 10 kg d) 14 kg

10. **Animals, especially humans, ingest thousands of microplastics per day that penetrate our body in various ways. This is due to ingestion through...**
    a) Inhalation
    b) Beverages
    c) Food
    d) All of these

11. **Estimated microplastics ingested (particles size 0-1mm) are through the consumption of common foods and beverages and the maximum ingestion happens through water only. The number of microplastics humans consume through water per week is**
    a) 1769
    b) 182
    c) 1000
    d) 1119

12. **82.4% of the tap water available in our country contains plastic fibers and per 500 ml the average number of plastic fiber present is**
    a) 4.5
    b) 4
    c) 4.9
    d) 2.2

13. **Inhalation in indoor places constitutes ingestion of higher amounts of microplastics entering the human body as compared to outdoors. It mainly comes from**
    a) Paints
    b) Synthetics textiles
    c) Dyes & Pigments
    d) All of these

14. **The tiny plastic fibers and fragments ingestion into the human body has long-term effects beyond a certain exposure level. The inhalation of plastic fibres seems to produce**
    a) Inflammation of the respiratory tract
    b) Cancers
    c) Infertility
    d) All of these

15. **Sea foods are mostly contaminated with micro and nano-plastics. These seafoods are consumed by humans through which injection happens. These are**
    a) Shellfish b) Mussels
    c) All of these d) Oysters

16. **Many additives used in plastic production are harmful to humans. Sufficient exposure can cause birth defects. These are**
    a) BPA
    b) Phthalates
    c) Flame Retardants
    d) All of these

17. **According to recent reports, which of the following age groups shows the highest intake of microplastics through diet?**
    a) Young adults aged 19-30 years old
    b) Teenagers aged 13-18 years old
    c) Children under 5 years old
    d) Elderly individuals above 65 years old

18. **What will happen to marine animals that ingest plastics and microplastics continuously? It will cause**
    a) Increased metabolism
    b) Enhanced vision
    c) Reduced buoyancy
    d) Improved digestion

19. **What are the health risks associated with the ingestion of microplastics in humans?**
    a) Increased energy levels
    b) Enhanced cognitive abilities
    c) Hormonal imbalances and organ damage
    d) Improved immune system

20. **Which of the following actions every individual can take to reduce the risk of plastic ingestion?**
    a) Increase the drinking water from single-use plastic bottles
    b) Increase the use of plastic containers to store food and beverages
    c) Consuming more pre-packaged foods
    d) Choosing glass or stainless steel containers for food and water

Answers

1.c	2.d	3.a	4.d	5.b	6.d	7.b	8.a
9.a	10.d	11.a	12.b	13.d	14.c	15.c	16.d
17.a	18.c	19.c	20.d				

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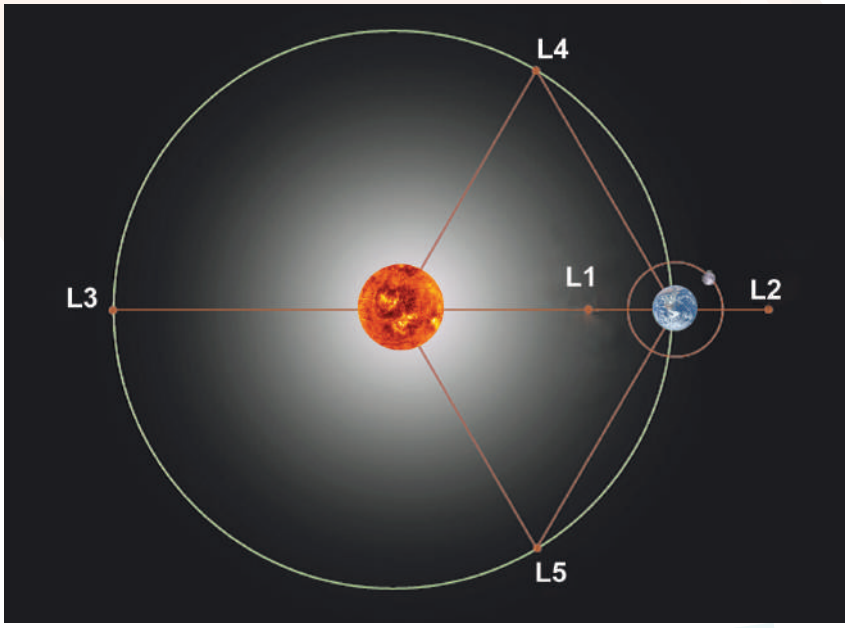
LAGRANGE POINT

India has recently launched its first space-based mission namely Aditya L1, to study the Sun. The spacecraft will be placed in a halo orbit around a Lagrange point of the Sun-Earth system, which is approximately 1.5 million km from Earth. The point provides a significant advantage, allowing the spacecraft to continuously view the Sun without any eclipses or occultation.

Can you identify the Lagrange point at which the spacecraft shall be placed in the image given below?



Answer:_____

Identify the image of the world's only scaly mammal

Answer:_____

SOLUTIONS TO THE PUZZLES PUBLISHED IN OCTOBER 2023

Hey! I am Chandrayaan-3

Do you know the names of my companions…

↓ L	T	Y	U	A	P	↓ S	O
→ I	↓ L	S	A	D	↓ C	H	J
B	→ R	A	M	B	H	A	N
S	A	R	S	T	A	P	O
Z	M	→ A	P	X	S	E	F
N	O	Q	Z	I	T	N	I
S	P	A	C	E	E	D	M

Lander Payloads

1. Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere (RAMBHA)
2. Chandra's Surface Thermo physical Experiment (ChaSTE)
3. Instrument for Lunar Seismic Activity (ILSA)
4. LASER Retroreflector Array (LRA)

Rover Payloads

5. LASER Induced Breakdown Spectroscope (LIBS)
6. Alpha Particle X-ray Spectrometer (APXS)

Propulsion Module Payload

7. Spectro-polarimetry of HAbitable Planet Earth (SHAPE)

My Timeline

Launch vehicle: LVM3 M4
On 1 August 2023: insertion in the translunar orbit
On 5 August 2023: insertion into the lunar orbit
On 17 August 2023: propulsion Module separated
On 23 August 2023: soft landing on South Pole of moon
On 24 August 2023: Although I was not there to witness this but yet happy to see Rover rolling out from Vikram lander

Online Biodiversity Drawing Competition 2020

Theme — "Conserve Biodiversity to Preserve Humanity"

Group II (Class IX-XII)

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