75 Years of S&T in India

75 YEARS OF INDIA'S INDEPENDENCE AND 80 YEARS OF CSIR

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SEVENTY-FIVE years of Indian independence, being celebrated nationwide as *Azadi ka Amrit Mahotsav,* is a momentous occasion for every Indian citizen. This is an occasion to remember and reflect on the sacrifices made by the millions of Indians in attaining our freedom. It also is a time to look back at the achievements and progress that we have made in these seventy-five years gone by. It is also an opportunity to envision a future that will have, among other things, science, scientific and traditional values at the core of India's development in the coming years.

India has made giant strides in its 75 years in almost all sectors. Be it health, education, transportation, communication, agriculture, science, and many other sectors, India has done very well. That said, there is always scope for improvement, and we need to take giant strides forward. India has a teeming youth population that allows the nation to dream of a vibrant future. It is a future that is laced with the raw energy and sparkling enthusiasm of the youth of this country.

CSIR, the early years

The science and technology ecosystem of India, primarily shaped by the efforts and programmes of the Ministry of Science and Technology, has done exceedingly well in embedding science into the nation's development. And when one speaks of science in India, the Council of Scientific and Industrial Research or CSIR is inextricably linked to the hundreds of technologies that CSIR has given to the nation. The 75th year of Indian independence is even more special to CSIR because CSIR enters its 80 years of gloriously serving the Indian society through S&T interventions.

The CSIR came into operation on 26 September 1942. Dr S.S. Bhatnagar, the first Director-General of CSIR, is revered as the father of research laboratories in India. In 1943, the Governing Body of CSIR approved a proposal of Dr S.S. Bhatnagar to establish five national laboratories — the National Chemical Laboratory, the National Physical Laboratory, the Fuel Research Station, the Glass & Ceramics Research Institute and the National Metallurgical Laboratory. Today, thirty-seven CSIR laboratories, including the 12 laboratories founded by Dr S.S. Bhatnagar, play a vital role in India's science and technology programmes.

Since early times, scientific research for technology development that can catalyse the growth of Indian industries was embedded in CSIR's operations. CSIR and its laboratories have evolved hundreds of technologies and products founded on science, scientific principles and scientific values. And many of these technological developments have come in the face of challenges and regimes of technology denials to India.

Although a large part of the CSIR budget comes from public funding,

considerable financial resources are raised from other sources, especially industries. When CSIR was established in 1942, CSIR appealed to the society for funding it, and the public donated a sum of Rs 44,000, which was a big sum of money at that time. This might be perhaps the earliest crowdsourcing of its kind to fund scientific research and development. Even at that point in time, industrial houses like Tata helped CSIR by funding. It is a matter of pride that CSIR partners with these and other industries to this day. Several decades later, CSIR and Cipla would give the world several low-cost anti-HIV drugs, and CSIR and TATA would develop a novel COVID-19 diagnostic kit.

Laying the foundation with basic research and industry association

Investment in basic science is essential. The fruits of such investment can be reaped in the form of technologies at the right time. The most recent story that exemplifies this is FNCAS9 Editor-Limited Uniform Detection Assay (FELUDA), CSIR's COVID-19 CRISPR-Cas based diagnostic kit. The CSIR-Institute of Genomics and Integrative Biology (CSIR-IGIB) had been working on the CRISPR-Cas based diagnostic kit for sickle cell anaemia for quite some time. When COVID-19 hit, the CSIR-IGIB team could quickly reorient this technique for developing a COVID-19 diagnostic kit. Not just developing the technology, but in partnership with TATA, CSIR has been able to go through the value chain to deliver the product in a record time to the market.

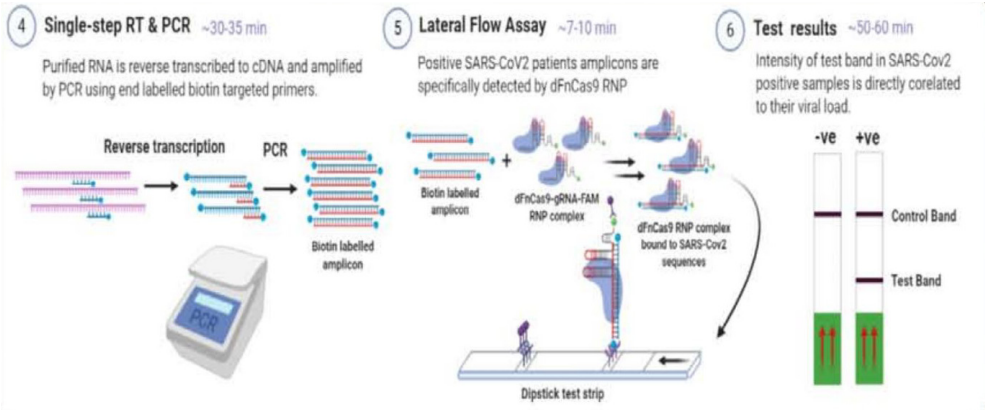
CSIR-IICT developed a cost-effective process for Favipiravir

CSIR has had a long and fruitful association with a large number of industries. During the most difficult and critical time when the COVID-19 pandemic hit India last year, CSIR laboratories churned out nearly one hundred COVID-19 technologies in a short span of six months. What is important is, CSIR laboratories were able to transfer over 60 technologies to many industries.

CSIR has had a long association with the pharmaceutical companies, and it takes pride in being the fountainhead of the generic pharma industry in the country. India produced some of the most affordable anti-HIV drugs. The credit for this goes to two of the CSIR laboratories, the CSIR-National Chemical Laboratory (CSIR-NCL) and the CSIR-Indian Institute of Chemical Technology (CSIR-IICT) that made the drug formulation process very cheap and handheld the pharma industry to manufacture the drugs at low cost and CSIR went global with these drugs. History repeated itself when during the COVID-19 pandemic last year, CSIR-IICT developed a cost-effective process for Favipiravir, and the process was transferred to Cipla. The drug was brought into the market in a quick time.

India has a rich legacy of traditional knowledge. Many of the ancient medical practices have been documented. However, these need to be validated from a modern scientific perspective. In this regard, CSIR has been involved in clinical trials of several ayurvedic formulations, and we have introduced several plant-based drugs. It is a matter of pride that during COVID-19, the first-ever phytopharmaceutical clinical trial was brought forth by CSIR in collaboration with Sun Pharma and the International Centre for Genetic Engineering and Biotechnology (ICGEB).

CSIR today is at the forefront to examine traditional medicines from the modern and scientific perspective, and the clinical trials in progress along with the Ministry of AYUSH will go a long way in validating the Indian systems of medicines such as those from the Ayurveda, Siddha and others from a modern scientific perspective.



FELUDA, CSIR's COVID-19 CRISPR-Cas based diagnostic kit

Technologies of the early years

CSIR, being one of the earliest S&T organisations in the country, was naturally bound to the challenges that a newly independent country faced. CSIR needed to participate in all those challenges. For example, when the Green Revolution was happening, one of the immediate challenges was mechanisation in agricultural operations. The CSIR-Central Mechanical Engineering Research Institute (CSIR-CMERI) in Durgapur

Swaraj tractor built by CSIR-CMERI

made the first tractor, the 20 HP Swaraj, licensed to Punjab Tractor Ltd. Likewise, when agri-pesticides had to be made, the CSIR-Indian Institute of Chemical Technology (formerly RRL, Hyderabad) produced several pesticides. These are a couple of integral roles that CSIR played during the Green Revolution.

CSIR's indelible voters' ink is an oft-told story, one that will always remain a cherished contribution of CSIR, not just because of its innovation but because it touches every voting adult in this greatest of democracies. Beginning with leaving an indelible mark on the fingers, hundreds of CSIR products and technologies have footprints on the lives of every Indian.

Indelible voters' ink – A CSIR innovation

In the 1970s and 1980s, when the buffalo milk had to be converted into powder form for transportation and as baby food, the CSIR-Central Food Technological Research Institute (CSIR-CFTRI) developed the required technology. That was a path-breaking innovation, and many do not realise that the Amul milk powder that is so widely used to feed infants is based on a CSIR technology.

CSIR's Kisan Sabha App connects farmers directly to transporters

During 1980, an era of technology denials, India faced difficulties purchasing supercomputers for academic and weather forecasting purposes. CSIR took upon the challenge, and the denial saw the arrival of CSIR's supercomputer. In 1986, the CSIR-National Aeronautical Laboratory (now National Aerospace Laboratories) initiated the Flosolver project, a parallel computing product for computational fluid dynamics. This outstanding effort had a far-reaching impact on how the world looked at India in that era of technology denials.

CSIR's Central Mechanical Engineering Research Institute in Durgapur played a vital role in designing the Mark II hand pump to draw groundwater. The installation of lakhs of Mark II pumps alleviated the problem of drinking water in many rural areas. To this day, this CSIR technology quenches the thirst of people in rural areas.

CSIR and innovations

India is a land of innovations. We see innovations all around us. From school children to the elderly, we have seen many examples of simple contraptions devised primarily to ease the way of doing things. Some of these frugal innovations serve immense practical purposes. On the other hand, science and technology-led innovations are also fundamental to any society. We have witnessed such S&T based innovations in various sectors, including strategic sectors such as space and defence.

Recently, CSIR-Centre for Cellular and Molecular Biology (CSIR-CCMB), in collaboration with the Indian Institute of Rice Research (IIRR), developed an improved variety of Samba Masuri rice with low Glycemic Index (GI) and blight resistance. Rice with low GI is considered suitable for people with diabetes. Consumption of food with low GI results in the slow release of glucose into the bloodstream, reducing the ill effects of diabetes. The CCMB-IRRI rice variety has the lowest GI of 50.99 against the usual 53 to 70 in several rice varieties. And being blight-resistant, it has a better yield and being a suitable grain type; the variety has enhanced its market potential and profit for farmers.

During the COVID-19 induced lockdown, when the farmers had difficulty transporting their produce to the vegetable markets or mandis, CSIR developed the Kisan Sabha App that connects the farmers directly with the transporters. The two key partners, the transporter and the farmers are connected directly without middlemen. Available in twelve Indian languages, this has brought about efficiency in the movement of agricultural produce and, without the middlemen, the profit margins of both the farmers and the transporters have increased.

India is the third country in the world to have its indigenous probe for DNA fingerprinting. It is a matter of pride that the DNA fingerprinting technology was developed by CSIR's Centre for Cellular and Molecular Biology. The technology has enabled

Ksheer Scanner developed by CSIR-CEERI for checking milk adulteration

providing justice to people, including those in many high profile criminal cases. Due to CCMB's efforts, the Centre for DNA Fingerprinting and Diagnostics (CDFD) under the Department of Biotechnology came into being.

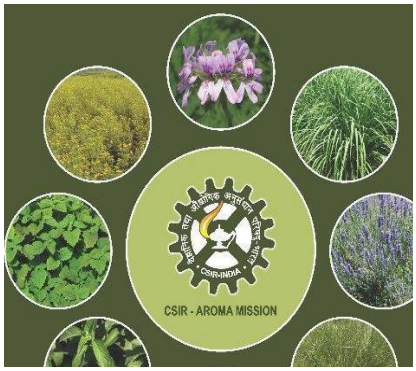
To detect adulteration in milk, CSIR-Central Electronics Engineering Research Institute (CSIR-CEERI) has developed Ksheer Scanner. CSIR also has a technology for detecting adulteration in mustard oil. CSIR gave the world, Saheli, the first non-steroidal once-a-week oral contraceptive pill. The pill is part of India's family planning programme and is exported to several countries globally.

Parboiling of rice is an ancient traditional process of India. As we know, the parboiling of rice has many advantages. It reduces grain breakage during milling, greatly improves the vitamins and other nutrients in the polished rice grain, increases the oil in the bran, reduces proneness to insect infestation, changes the rice's cooking and eating quality, and reduces the rice's quality loss of nutrients during cooking. The technology for parboiling and drying plant – 4 tonnages per hour (TPH) capacity has been developed at CSIR-Central Food Technological Research Institute, Mysore, using the appropriate equipment for optimal product recovery of the right quality.

The CSIR Heeng Story

In the year 2020, CSIR introduced the cultivation of asafoetida or heeng in India for the first time. Despite India being the largest consumer of heeng globally, this household spice is not cultivated in India and is imported from Afghanistan, Iran and other countries. CSIR's Institute of Himalayan Bioresource Technology (CSIR-IHBT) carried out ecological niche modelling to investigate landscapes that meet the ecological requirements of the asafoetida plant. Based on these studies, the Institute identified Ladakh, Himachal Pradesh, Jammu & Kashmir, and Uttarakhand as suitable regions for heeng cultivation in India.

The challenging process of introducing the plant in India began in 2017. CSIR-IHBT contacted several countries for obtaining the requisite



plant material. The ICAR's National Bureau of Plant Genetic Resources (NBPGR) issued an import permit for bringing the heeng seeds to India. After that, several scientific interventions were introduced by CSIR-IHBT right from germination through nursery raising and transplantation and field trials in different locations. The Institute did hydroponic cultivation and mass propagation of heeng using tissue culture techniques. Molecular and biochemical studies such as DNA barcoding for authentication of the plant species, volatile compounds and metabolites profiling were also carried out.

Be it COVID-19 technologies or the introduction of heeng, CSIR is focused on the nation's Atmanirbhar Bharat vision.

Aroma mission of CSIR

A more recent contribution of CSIR that has touched the lives of thousands of farmers, improving their profit and creating hundreds of entrepreneurs is the Aroma Mission. CSIR introduced and hand-held the cultivation of medicinal and aromatic plants in many

The Aroma Mission of CSIR has improved farmers' incomes

regions of the country, including the remote northeast regions and facilitated setting up distillation units for farmers to produce the aromatic oils.

CSIR also played a vital role in mentha, lavender and saffron cultivation in the country. The Aroma Mission has been a very successful programme of the country that, in the coming years, will pan out across the country and have hundreds of acres and thousands of farmers cultivating and producing medicinal and aromatic plants and developing plant-based products thus enabling higher earnings and profits.

Intellectual property and traditional knowledge

TKDL developed by CSIR documents India's traditional knowledge

In the 1990s, CSIR, through its rather aggressive intellectual property protection efforts, laid the foundation of IP protection in the country. CSIR, while carrying out cutting-edge scientific research, is also very mindful of the traditional systems and the ancient scientific knowledge of this country. When attempts were made to misappropriate some of India's traditional knowledge concerning neem, turmeric, basmati and so on, India, led by CSIR, fought nothing less than a battle to prevent the misappropriation of India's traditional knowledge.

This also led CSIR to set up the Traditional Knowledge Digital Library (TKDL), which now has been twenty years in existence. TKDL continues to document India's traditional knowledge and pushes back or fights any attempt by anyone to appropriate India's ancient expertise as their own.

Tejas, light-weight combat aircraft, developed by CSIR-NAL

CSIR and the strategic sectors

Defence and space are two exceedingly important strategic sectors that have implications for national security as well. While India has very efficient and dedicated space and defence programmes and systems, institutions such as the CSIR also contributed to these sectors.

Head-Up Display (HUD) is an essential aid to aircraft pilots, especially in fighter aircraft. It is a transparent display that presents data without requiring the pilot to look away from their usual viewpoint. HUD displays flight information such as altitude, airspeed, angle of attack, navigation, weapon aiming and other flight information in the collimated form so that the pilot can view the information with his head "up" and looking forward, instead of looking down on other instruments mounted in the cockpit. This high-tech system has been developed by the CSIR-Central Scientific Instruments Organisation (CSIR-CSIO) in Chandigarh. CSIO began developing the technology from scratch after the UK, USA, France, and Israel declined to share it with India. This technology was first adapted for the indigenous light combat aircraft Tejas.

And talking of lightweight combat aircraft, one of the challenges in the aircraft industry has been to lower the aircraft's weight. This is done by using lightweight materials such as composites. It is no small achievement that Tejas, the light Indian aircraft, comprises composite materials that are 45% of its weight. Out of this, about 25% was designed and developed at CSIR-National Aerospace Laboratories (CSIR-NAL). Over the years, CSIR-NAL has developed many other critical technologies for Tejas and the aviation sector in general.

Autoclaves are required to manufacture superior quality structural components containing high fibre volume fraction and low void content. The autoclave is a pressure vessel that provides the curing conditions for the composite where vacuum, pressure, heat-up rate and cure temperature are controlled. High processing pressures allow the moulding of thicker sections of complex shapes. Honeycomb sandwich structures can also be made to a high standard, typically at lower pressures.

CSIR-NAL has successfully developed state-of-art Indigenous Autoclave Technology to process advanced lightweight composites integral to modern-day civil and military airframes. The autoclaves' size ranges from smaller lab-scale to very large sizes up to 5m working dia and 12m working length. These meet the requirements of the aerospace industry, research and educational institutes.

In the last 7-8 years, several autoclaves have been supplied to various organisations in the strategic sector and academic institutions. About 500 million rupees worth of business has been generated as of date. The autoclave technology has successfully

promoted the local ecosystem, mitigating imports and creating millions of employment man-hours.

Large sums of money are spent every year on aviation fuel. To lower the cost and also reduce pollution, CSIR has been working on developing biofuel. In December 2018, the Indian Airforce Pilots flew India's first military flight using blended bio-jet fuel. The fuel, made from Jatropha oil, was processed at CSIR-Indian Institute of Petroleum (CSIR-IIP), Dehradun. It was a proud moment for CSIR and the country when the first biofuel flight of the Indian Air Force did a flypast on India's Republic Day in 2019. Biofuel technology holds a lot of promise as it is carbon-neutral, reduces air pollution, and is likely to bring down import bills on crude oil.

From space to the seas

The year 2021 marks India's 40th scientific expedition to Antarctica. The Indian journey marks four decades of the country's scientific endeavour to the southern white continent. The Indian Antarctic expeditions began in 1981. As we know, the Indian Antarctic programme built three permanent research base stations in Antarctica — named Dakshin Gangotri, Maitri, and Bharati. As of today, Maitri and Bharati are operational.

Currently, the National Centre for Polar and Ocean Research (NCPOR), Goa, manages the Indian Antarctic programme. However, we might recall that the first Indian expedition to Antarctica was launched from CSIR-National Institute of Oceanography (NIO), Goa, which comprised 21 scientists and support staff led by Dr S.Z. Qasim, the then Director for the CSIR-National Institute of Oceanography.

CSIR-National Institute of Oceanography has been undertaking scientific expeditions in the oceans for several decades now. Even during the ongoing COVID-stricken year, CSIR-NIO undertook the largest scientific expeditions ever with 30 scientists that will cover 11,000 nautical miles in 90 days aboard the NIO research vessel Sindhu Sadhana.

CSIR and the leather sector

The leather industry occupies prominence in the Indian economy because of its massive potential for employment, growth and exports. The leather and footwear industry directly employs approximately 4.5 million people, with more than 30% being women. The CSIR-Central Leather Research Institute (CSIR-CLRI) has interwoven its research efforts to meet industry training needs since the time industry was operating in the cottage sector. The Institute has given several technologies to the leather sector. Some of the latest technologies include waterless chrome tanning process, electro-oxidation based zero wastewater discharge, smart leathers, compost for agricultural applications, product for dry tanning, high-value collagenous products and activated carbon from trimming and fleshing wastes, preservation-cum-unhairing process and biogas for energy conservation. The transfer of such technologies to the leather and leather product industries (existing and start-ups) has increased the existing employee base and new job creation.

CRIR-NIO's RV Sindhu Sadhana undertook the largest scientific expedition recently

Science and the public

Apart from its intense R&D efforts, CSIR has been engaged in inculcating scientific temper in school children. The CSIR's Jigyasa program is a unique platform for bringing scientists and teachers to nurturing young minds. This program envisages opening up the national scientific facilities to school children, enabling CSIR scientific knowledgebase and facility to be utilised by schoolchildren. This model of engaging school children also has been extended to other schools in addition to KVS. To date, over 3,00,000 school students have participated in the Jigyasa programme.

The engagement of scientists and scientific institutions with the public is vital. It is the duty and responsibility of scientists to communicate and share their scientific research with their peers and the public. The citizens have a right to know, and importantly, such communication efforts can inspire the younger generation to take up science. CSIR is conscious of these facts and has a system in place for public engagement and outreach. During the COVID-19 pandemic, outreach became a regular feature, and we had numerous webinars in several Indian languages that addressed various aspects of COVID-19. We received very favourable responses from the public. Recently, we have initiated a webinar series that is showcasing the

Students interacting with former S&T Minister and President of India as a part of Jigyasa programme

success stories of CSIR. We plan to showcase at least 80 success stories as a part of the *Azadi ka Amrit Mahotsav* celebrations.

Fostering and catalysing technology development

In addition to doing its research and technology development, CSIR fosters and catalyses technology development by researchers and technologists in other organisations. This is done through the different programmes. One such programme is the New Millennium Indian Technology Leadership Initiative (NMITLI). NMITLI seeks to catalyse innovation centred scientific and technological developments as a vehicle to attain for Indian industry a global leadership position, in selected niche areas in a true "Team India" spirit, by synergising the best competencies of publicly funded R&D institutions, academia and private industry. This most extensive public-private partnership R&D programme in the country has given numerous innovative technologies.

A recent innovation has been the development of dental implants. Under the NMITLI funded programme, researchers from the Maulana Azad Institute of Dental Sciences and the Indian Institute of Technology developed dental implants that cost half the price of the imported implants.

CSIR-Central Salt and Marine Chemicals Research Institute's spent wash management technology that recovers potash, a beneficial fertiliser, from the waste of sugarcane processing industries has also been noteworthy. This waste to wealth technology of CSIR-CSMCRI not only recovers valuable fertiliser but also lowers pollution and even yields cattle feed.

With CSIR entering its 80th year of existence, it is only natural that many CSIR institutes and laboratories are celebrating their own milestones. Earlier this year, CSIR-National Physical Laboratory (NPL) celebrated its 75th anniversary. Shri Narendra Modi, Honourable Prime Minister, graced the celebratory event and gave his inaugural address. CSIR-NPL has been the standards bearer of the country and, on its 75th anniversary, dedicated the National Atomic Timescale and *Bhartiya Nirdeshak Dravya Pranali* (Indian Reference Materials) to the Nation.

It is indeed heartening that CSIR has been receiving the support and patronage of India's highest offices. Such support strengthened by the decades of solid and long-lasting partnerships with Indian industries and the acknowledgement of the public of CSIR's contributions has kept the wheels of CSIR rolling for 80 long years now.

The contributions of CSIR to the nation are so vast and varied that the likelihood of a direct or indirect CSIR footprint in any sphere is very high. Solid waste management, electricity generation from vegetable or plant wastes, environmental protection, mine safety, construction of low-cost hazard resistant houses, unravelling India's underwater cultural heritage, one could go on.

Needless to say, CSIR has played a significant role in the 75 years of Indian independence. It is difficult to recount all the manifold contributions of CSIR of its last eighty or so years in a few pages. In recent years, we have initiated steps to transform CSIR into a globally competitive organisation. The transformation entails a series of essential changes to align to the changing times and fulfil new societal needs. Earlier this year, two national institutes, the CSIR-National Institute of Science Communication and Information Resources (CSIR-NISCAIR) and the CSIR-National Institute of Science, Technology and Development Studies (CSIR-NISTADS) were merged to form the CSIR-National Institute of Science Communication and Policy Research (CSIR-NIScPR). The creation of the new entity will strengthen S&T communication and S&T policy research in the country.

It is a long road ahead for CSIR, but what is certain is that a *New CSIR for a New India* will continue to play a critical role in India's science and technology ecosystem for many more decades to come.