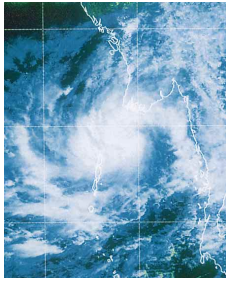


CHAPTER XXV

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

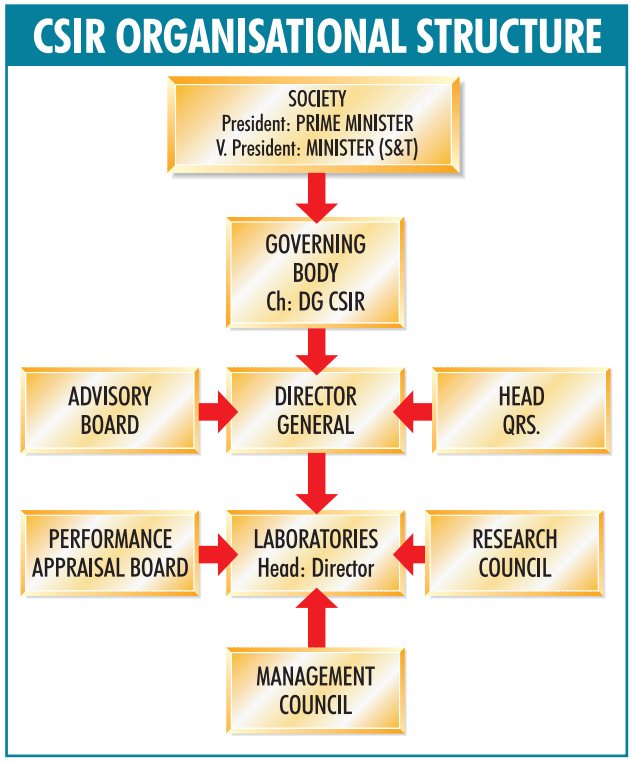
The Council of Scientific and Industrial Research (CSIR) is the name of the nation-wide research platform consisting of a network of laboratories which spans the geographical dimensions of India. Its programmes which bridge various disciplines, address specific needs which arose in the process of social transformation in the post-colonial context and demands which our society faces in this period of globalization.

This multidisciplinary and multilocational council runs 39 laboratories and 80 field centres which carry out fundamental and applied R&D in all areas of science and technology, barring atomic energy. The dynamic dimension of the network is the pool of knowledge and expertise of over 5000 active scientists of repute, supported by over 10,000 scientific and technical personnel. This scientific infrastructure was built up over six decades at a cost of equivalent to 1 billion US dollars at current value.

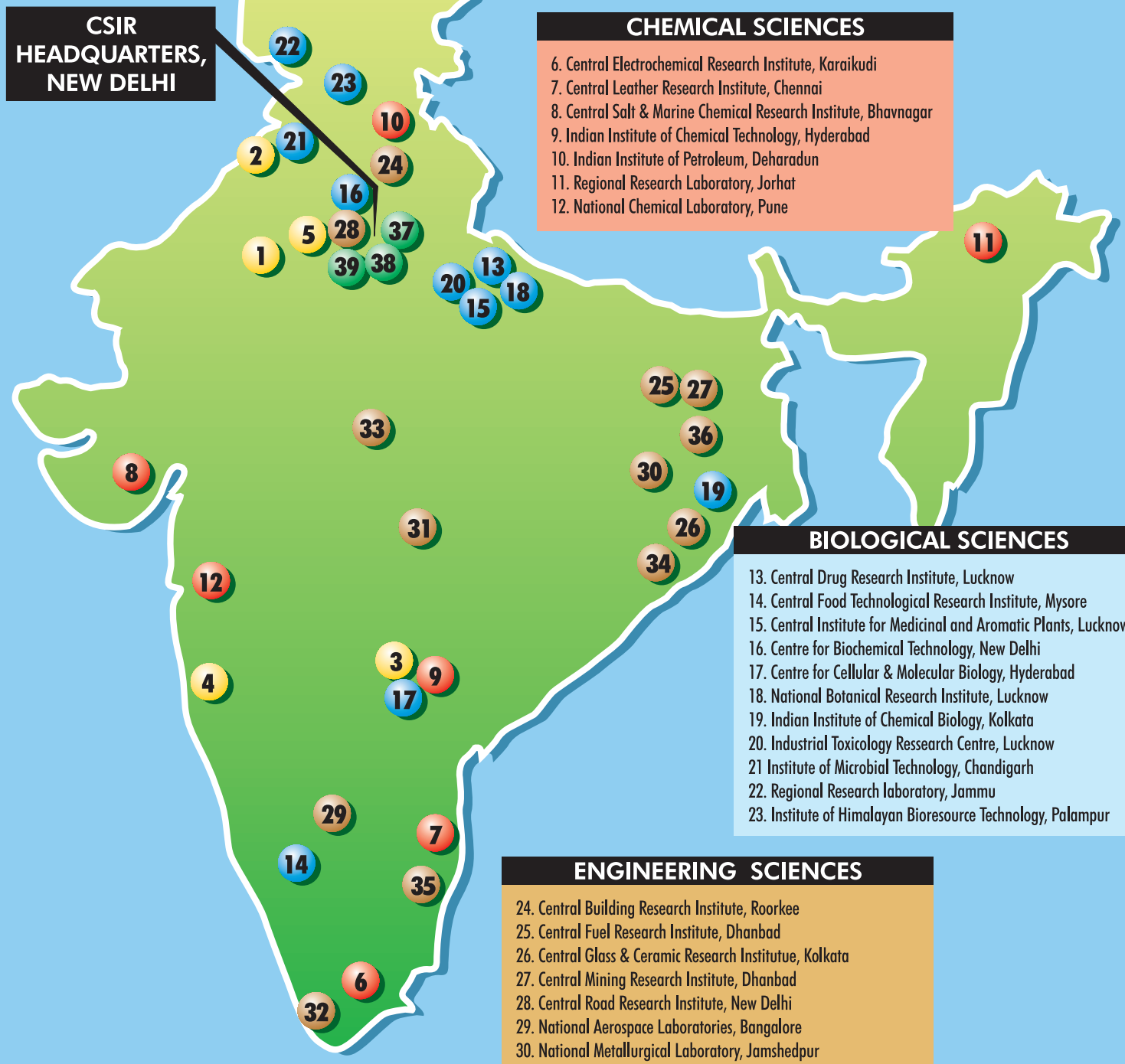
The foresight of its founding vision has been vindicated by CSIR's capability to serve not only as a national R&D infrastructure but also a platform for international collaboration and research projects, thanks to its interlaboratory and interdisciplinary experience. It now works on an annual budget of around $250 million.

The CSIR was established in 1942 as a autonomous, non-profit organization with a wide ranging charter of functions. These included promotion, guidance and co-ordination of scientific and industrial research, collection and dissemination of information on research and industry, founding of laboratories to carry forward scientific and industrial research and utilization of the new knowledge so generated for development of industry. CSIR was also charged with other tasks such as rendering assistance to other institutions conducting research, awarding of fellowships and publishing of scientific journals.

As a springboard for scientific and technological activity, CSIR helped usher India into



CSIR INDIA NETWORK OF R & D LABORATORIES



PHYSICAL SCIENCES

1. Central Electronics Engineering Research, Institute, Pilani
2. Central Scientific Instruments Organisation, Chandigarh
3. National Geophysical Research Institute, Hyderabad
4. National Institute of Oceanography, Goa
5. National Physical Laboratory, New Delhi

CHEMICAL SCIENCES

6. Central Electrochemical Research Institute, Karaikudi
7. Central Leather Research Institute, Chennai
8. Central Salt & Marine Chemical Research Institute, Bhavnagar
9. Indian Institute of Chemical Technology, Hyderabad
10. Indian Institute of Petroleum, Deharadun
11. Regional Research Laboratory, Jorhat
12. National Chemical Laboratory, Pune

BIOLOGICAL SCIENCES

13. Central Drug Research Institute, Lucknow
14. Central Food Technological Research Institute, Mysore
15. Central Institute for Medicinal and Aromatic Plants, Lucknow
16. Centre for Biochemical Technology, New Delhi
17. Centre for Cellular & Molecular Biology, Hyderabad
18. National Botanical Research Institute, Lucknow
19. Indian Institute of Chemical Biology, Kolkata
20. Industrial Toxicology Ressearch Centre, Lucknow
21 Institute of Microbial Technology, Chandigarh
22. Regional Research laboratory, Jammu
23. Institute of Himalayan Bioresource Technology, Palampur

ENGINEERING SCIENCES

24. Central Building Research Institute, Roorkee
25. Central Fuel Research Institute, Dhanbad
26. Central Glass & Ceramic Research Institutue, Kolkata
27. Central Mining Research Institute, Dhanbad
28. Central Road Research Institute, New Delhi
29. National Aerospace Laboratories, Bangalore
30. National Metallurgical Laboratory, Jamshedpur
31. National Environment al Engineering Research Institute, Nagpur
32. Regional Research Laboratory, Thiruvanathapuram
33. Regional Research Laboratory, Bhopal
34. Regional Research Laboratory, Bhubaneshwar
35. Structural Engineering, Research Centre, Chennai
36. Central Mechanical Engineering Research Institute, Durgapur

INFORMATION SCIENCES

37. National Institute of Science, Technology and Development Studies, New Delhi
38. Indian National Scientific Documentation Centre, New Delhi
39. National Institute of Science Communication, New Delhi

SCHEMATIC DIAGRAM NOT TO SCALE

a scientific milieu, creating and nurturing talent in science, innovation and technology. It spawned many organizations, many disciplines and most importantly has served as a nursery and training ground for India's talented scientists and technologists.

On one hand, CSIR has assisted industry in the development of viable and globally competitive technologies and on the other, has provided back-up support in exploration and exploitation of indigenous raw materials and natural resources for import substitution, pollution control and effluent treatment, waste utilization and energy conservation. CSIR's inherent strength lies in its ability to form special interdisciplinary, inter-laboratory, international groups to tackle specific research and development problems. To cite one example, a consortium of 20 CSIR laboratories, 10 universities and three organizations dealing with traditional systems of medicines, is working in a 'Team India' initiative to synergies high science with traditional wisdom and India's rich biodiversity to discover and develop bioactives from plant sources. In yet another endeavour, CSIR laboratories have teamed up with academia, steel industry and government to develop mathematical models to stimulate steel production in a blast furnace. There are many more other similar alliances.

A Proud Record

CSIR has several radical scientific achievements to its credit, such as: the induction of precocious flowering in plantlets of bamboo raised in tissue-culture, discovery of one of the (then) smallest protein molecules, seminal plasmin; the first formulation of a model of crack-tip energy dissipation; the first combined genetic and physical map of the whole *V. cholerae* genome; the development of a salt sensitive expression vector, used successfully to clone and express six divergent genes; the elucidation of the mechanisms for delaying the formation of cataract in the human eye; the first study to give an understanding of the outer ionosphere and may others.

CSIR

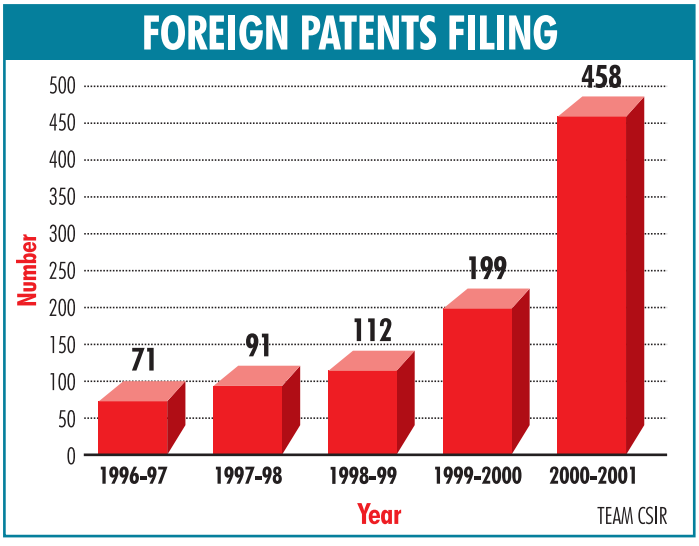
- A 59 year young, not-for-profit R&D organization
- Prime Minister of India as President
- 39 laboratories, 80 outreach centers, spread nation-wide
- 22,000 strong work force
- 5000 Scientists/technologists
- 2,500 Doctorates

CSIR's R&D Services:

- Aerospace & Aeronautics
- Bio-sciences & Bio-technology
- Chemicals & Chemical Technology
- Coal, Gas and Petroleum
- Construction Technology
- Drugs & Pharmaceuticals
- Earth & Ocean Resources
- Ecology & Environment
- Electronics & Instrumentation
- Food Processing
- Leather & Leather Goods
- Machinery & Equipment
- New Materials
- Mining & Metallurgy

- Value of R&D infrastructure over USD 1 billion
- Annual Budget USD 250 million
- Over 1000 CSIR technologies commercially exploited
- USD 1 billion worth of industrial production per year
- 2000 scientific papers published per year
- 500 Indian & 650 foreign patents filed per year
- Bilateral Scientific Collaboration with 30 Organizations in 27 countries

On the technology front, CSIR performance is equally impressive. CSIR announced an intellectual Property Policy in 1995 and has gone on to file annually around 500 patents in India and around 650 patents abroad, the numbers being higher than those of any single Indian organization. Over the years it



has developed more than 3,000 technologies and licensed 1,500 of them to about 6,000 clients. The annual industrial production based on CSIR techniques and technologies is estimated over $1 billion. Its S&T services and inputs annually generate productivity savings of around $500 million.

CSIR was the first to introduce buffalo milk for baby food (brand name 'Amul'); it launched the wholly indigenous tractor *Swaraj*; developed a cost-effective process for drugs for mass use; it initiated the design of building foundations suitable for black cotton soil; it was the first to extract polymetallic nodules from the Indian ocean bed, based on which India became the first country in the world to be granted 'Pioneer Status', under the UN treaty on the Law of Seas; it built an all-composite small aircraft, *Hansa*. Significant S&T activities and achievements are spread across a wide range of areas.

Aerospace S&T: The National Aerospace Laboratories (NAL), Bangalore, of the CSIR is a major player in India's aerospace programmes. It has developed world class capacity for design, development and fabrication of large components of advanced composites for civilian and combat aircraft, structural testing and analysis, aerospace electronics and systems, innovative capabilities in surface engineering etc. The activities are focussed on design, development, fabrication and airworthiness testing of small civilian aircraft and on creating, maintaining and providing high class expertise and world class test and certification facilities, such as National Trisonic Acoustic Facilities, Aerodynamics Test Facilities, Full-scale Fatigue Test facility, FRP and composites pilot plant facility. NAL is now spearheading the initiative to create a civilian aircraft industry in the country. It has already developed, designed, fabricated a two-seater trainer aircraft, *Hansa*-3, which has been certified for day and night flying. It is now engaged in the design, fabrication and airworthiness testing of a 9 to14 seater multipurpose light transport aircraft.

Left: Saras, 14-seater light transport aircraft. Right: Two-seater trainer aircraft Hansa-3, which has been certified for day and night flying.

Development of Drugs by CSIR Laboratories

The major players are CDRI Lucknow, IICT Hyderabad, NCL Pune and RRL Jammu.

Responsible for developing and licensing 12 new drugs to the industry.

Developed and transferred technology for over 100 drugs and intermediates. About 30 major drugs and a dozen intermediates being currently produced with CSIR developed technology.

Services offered include consultancy, contract and collaborative research, assimilation and modification of imported technology, training and data search and analysis.

Providing help and consultancy to international agencies like UNIDO, UNCTAD, WHO.

Biology and Biotechnology: CSIR's contributions in this area have been wide ranging including genomics, control of gene expressions, recombinant DNA products, to molecular and cellular biology, tissue culture, agrobiotechnology and fermentation. It had the distinction of placing India among the first few nations to develop its own multi-locus, BKm derived probe for DNA fingerprinting. Pioneering work has also been done on leishmania, cholera, cataract formation in the eye, apoptosis, and antibacterial properties of plant material. It has also developed several PCR based markers and diagnostic systems.

The development of elite genotypes of *Mentha arvensis* has enabled India to contribute mentha-*menthol* to the world as the leading producer of this product, along with the development of many novel and improved strains for several medicinal, aromatic and flowering plants.

Chemical Sciences and Technology

The area of chemical science and technology is the one in which CSIR's work has enjoyed high visibility, consequently bringing along credibility with the chemical industry, in areas of agrochemicals, drugs and pharmaceuticals, petroleum and petrochemicals, catalysts, and chemical intermediates, subsectors that call for a high level of innovativeness.

Over 30 new and cost-effective agrochemical processes have been developed for the production of a whole range of organophosphorous pesticides. Later, the focus was turned on the development of pheromones and biopesticides. In the area of drugs and pharmaceuticals, the country felt the need for cost-effective and commercially viable technologies for a wide range of essential drugs. The development, consequently, of such drugs as for example anti-cancer, anti-virals, anti-bacterials, anti-glaucoma, anti-inflammatory, analgesics, and cardio-vascular drugs among others, gave the much needed fillip to a nascent Indian drug industry to emerge as the largest producer of generic drugs in the world. At the same time CSIR had the distinction of bringing 12 entirely new drugs into the market.

Catalysts: CSIR Success Story

1970s	Learning: Import substitution DMA, Vanadium Pentaoxide, Raney Nickel
1980s	Catching-up: Improved catalysts bimetallic for reforming, nickel Alumina for hydrogenation, iron oxide for dehydrogenation
1990s	Global emergence: Improved & new catalysts : formaldehyde, methylethyl Ketone, Xylene isomerization
2000	Global stature: Novel catalysts & processes: Linear alkyl benzene, adipic acid, biphasic catalysts, methane to higher hydrocarbons.

India is among the top five countries that possess world class capabilities for development and manufacture of new catalyst formulations. Starting from developing known catalysts, CSIR introduced its own brand of new zeolite catalysts, named 'encilites', for diverse industrial processes. It introduced the novel concept of promoting interfacial catalysis in a biphasic system for the

Petroleum Process: Commercially Adopted

Product	Technology Partners	Commercial Usage
Benzene & Toluene Extraction	CSIR, EIL	BPCL, CRL
Xylene Isomerisation	CSIR, IMCL, EIL	IPCL
Food grade Hexane	CSIR, EIL	BPCL, MRL
Toluene Disproportionation	CSIR, IPCL, EIL	IPCL
Sulpholane	CSIR	CADILA
Hot Rolling Oil	CSIR, SAIL	LUBRIZOL INDIA
Lobs using NMP Extraction	CSIR	IOC
Bimetallic Reforming Catalyst	CSIR, IPCL	IPCL, MRL
Visbreaking	CSIR, EIL/S&W	IOC
Delayed coker	CSIR, EIL	IOC

hydroformylation of several olefins using a rhodium complex. Efforts in this science based sector have yielded fruits and India now exports catalysts to the world including the western markets.

In the area of petroleum processing, a near-cartel situation on technology has been prevailing worldwide. CSIR, in association with its partners, has helped to break the stranglehold, having successfully developed processes that are now commercially adopted by several Indian refineries and grass-root plants.

Significant contributions in the chemical sector have also been made in the area of chemical intermediates. Process technologies were developed and utilised by industry for benzyl chemicals, glyoxal, sodium azide cyanuric chloride, hyderazine hydrate, phosgene, CFC substitutes etc. World class capabilities and facilities exist in the country today to provide for hazard evaluation, risk analysis, safety management, mathematical modelling and simulation.

Coal: In the early years CSIR helped in the setting up of all the coal washeries in the country and defined the washability index of coals for the first time. Since then, work has continued on developing new approaches to coal fines beneficiation and recovery from the washeries, design of mini-flotation plants etc. It has helped the steel industry to decide on coke blends; the power industry to evolve washing strategies and, most importantly, it has enabled the myriad small and medium sized beehive coke units in the coal belt of India to produce coke efficiently, with minimum pollution from inferior coals. There have been a pioneering endeavours in the developmental process in coal gasification and conversion of coal to liquid fuels.

Electronics: The electronics industry in the country has benefited largely from professionally developed specialized products. These include electronic systems for excitation control for the sugar and paper industries, diesel electric locomotives, AC drives for mining locomotives, three phase to single phase thyristor convertors, and a host of special purpose analytical and field instruments. CSIR is the repository of high-tech knowledge in microwave and travelling wave tubes and in klystrons and magnetrons. The capabilities in semiconductors created in its labs have provided tailor-make hybrid microcircuits for the Indian space programme and for other applications.

Food: In the area of food and food processing, several novel cost-effective and easy-to-operate techniques and processes have been developed by its laboratories in India. These cover the storage, conservation and processing of foodgrains, as also technologies for low-cost nutritious foods, food preservation, 'convenience foods' and non-conventional foods. S&T inputs have also gone into spices and spice products, grain-based foods of both the convenience and the speciality kinds, into the preservation, packaging and transportation of fruits and vegetables. Attention has been paid to develop appropriate and improved designs for machinery, such as those for milling for grains and pulses and other for food-packaging.

Housing and Construction: Modern techniques and technologies have been carefully developed to cover the whole gamut of construction activities, right from laying of foundations to fashioning of required construction equipment. CSIR designs for foundation for piles – under-reamed, bored, compaction, skirted, spliced -- are variously aimed to enable sound construction on varying types of soils encountered in the country. Newer and innovative building components developed have greatly helped the building industry to standardize optimal structural elements, such as RCC channel unit, RC ribbed slabs for floors and tiles, pre-cast stone concrete blocks, prefabricated brick panels. Alternative materials which have come out of sustained R&D work utilize waste, economise on energy and are eco-friendly. These products include fly ash bricks, sand lime bricks, red mud bricks, tiles from ferrochrome wastes, gypsum plaster boards, glass reinforced gypsum as wood substitute, corrugated roofing sheets from coir or wood-wool and ferrocement. In the area of structural engineering, CSIR laboratories have specialized in making design and analysis of special and complex structures such as highrise, longspan, suspended, offshore structures and of ships, and in the integrity assessment of these structures. The roads sector has also benefited from designs and constructions techniques, especially those honed for using local skills and materials.

CSIR's Contribution to Industrial Development

Drugs & Pharmaceuticals	Pioneered effective processes & new drugs development for self.
Pesticides	Catalysed domestic industry
Leather	Propelled industry for value addition, modernization and environment conciousness.
Petroleum & Petrochemicals	Novel processes for techno logical self-reliance & global positioning
Food Processing	Appropriate techniques & technologies for conservation & productivity
Building Materials	Utilization of wastes and endogenous resources
Economic Plants	Introduced & popularized new high value varieties of medicinal and aromatic plants.

Leather: The Central Leather Research Institute (CLRI) of CSIR is the largest leather institute in the world. Its S&T inputs and extension activities have been actively transforming the traditional leather industry into a modern, vibrant and environmentally responsive one. Pioneering contributions have been made at every stage of the industry's activity -- starting from techniques for the flaying of dead animals and the storage of skins, using either no salt or very minimum, going on to appropriate time-saving and low-pollution tanning and processing techniques using 'low chrome' and 'no chrome' tanning chemicals, to modernization of the net operations in tanning through computer application and subsequently proceeding to develop new techniques for generating value added speciality leathers, computer-aided designs for footwear, garments, and goods, fashion colour forecasting, export certification and, not the least of all, in creating both the human resources as well as the R&D that the leather industry and the sector needs. A pioneering Leather Technology Mission has been mounted for the sustainable development of the Indian leather industry which aims at vast grass-roots coverage.

Materials: From time to time, demand for special materials has arisen from sectors like aerospace, defence or sophisticated industries for developing such materials. Among them are: Electronic materials such as amorphous and polycrystalline silicon, ferrites, gallium, luminescent phosphors for display, piezoelectrolytics, high-purity alumina, conducting polymers and silver pastes;

- Aerospace materials such as high-density carbon-carbon composites, Nalar--a Kevlar equivalent high strength fibre, aluminium-lithium alloys, high purity aluminium;
- Industrial materials for special performance such as silicon carbide, silicon nitride bonded silicon

carbide, silicon carbide whiskers, aluminium-metal matrix and aluminium-graphite composites, special glasses for optical fibres, infrared range finders, laser glasses, radiation shielding glasses and sol-gel techniques for glass coatings etc.;

- Superconducting materials.

Metals and Metallurgy: In the metals and metallurgy sector, technologies developed by CSIR have been utilized to establish the first plants in India for magnesium, chromium, carbon free ferro-alloys, ferro-vanadium, zirconium and titanium powders and titanium electrodes. Besides it has developed novel processes for the direct reduction of iron ore to sponge iron for mini steel plants, and the technology for the processing of polymetallic sea nodules for recovery of valuable metals; gasfired cupola for use in cast iron foundries and high grade synthetic rutile.

Minerals: CSIR has contributed in a large measure for exploitation of low grade and inferior ores by devising flowsheets for copper concentrators, manganese pan sintering, iron ore washing and sintering, low grade fluorspar and graphite beneficiation, recovery of molybdenum, nickel and copper, beneficiation of low grade chromite ores, graphite etc. More significantly, it has recently set-up a technology demonstration plant for recovery of nickel from low assay chromite overburden.

Mining: CSIR has made significant contributions to all aspects of mining operations, especially in coal mines (to the exclusion of only heavy mining equipment). Studies and efforts on subsidence prediction and control have enabled the extraction of coal locked up in pillars and underneath surface structures and water bodies. CSIR has been the principal agent for designing appropriate mine ventilation systems and is now the main resource for mine disaster management in the country. It has devised appropriate roof support structures for bolting and stitching such as, hydraulic and screw props, safari clamps, triangular chock, etc. which are now being manufactured by scores of small scale units in the mining region of Bihar. It is responsible for testing and certifying the safety equipment for miners' personal and flame proof quality of electrical equipment etc.

Ecology and Environment: When S&T inputs are needed to evolve national policies and to ameliorate environmental problems, CSIR is a major contributor. It has developed expertise in air, water and soil quality management, analysing onshore, offshore and atmospheric environment, near-space environment, ionospheric chemistry, stratosphere-mesosphere coupling, 'toxic & hazardous' waste management and carrying capacity and environmental impact and risk assessment studies.

Scientific Publications

CSIR publishes 15 primary scholarly science journals – the latest introduction being Indian Journal of Intellectual Property Rights and Journal of Traditional Knowledge. It brings out 10 bulletins on specific science area such as electro-chemistry, fuel science & technology, mining research, mechanical engineering, medicinal and aromatic plant sciences etc.

International Collaboration

CSIR fosters symbiotic S&T cooperation with its counterparts abroad through bilateral and multilateral co-operation and exchange programmes. It has S&T collaborative agreements/arrangements with 30 agencies in 27 countries. It has also been participating fully in the activities of the Commonwealth Science Council, the Association for Science Cooperation in Asia, the South Asia Association for Regional Cooperation, the World Association of Industrial and Technological Research Organizations, the Canadian International Development Research Centre, and the Third World Academy of Sciences (TWAS). With TWAS it operates fellowships, both for post-Doctoral Research and for post-Graduate studies, in CSIR laboratories.