ANNUAL REPORT 1995-96

LBMK/NSL

COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH

ANNUAL REPORT
1995-96



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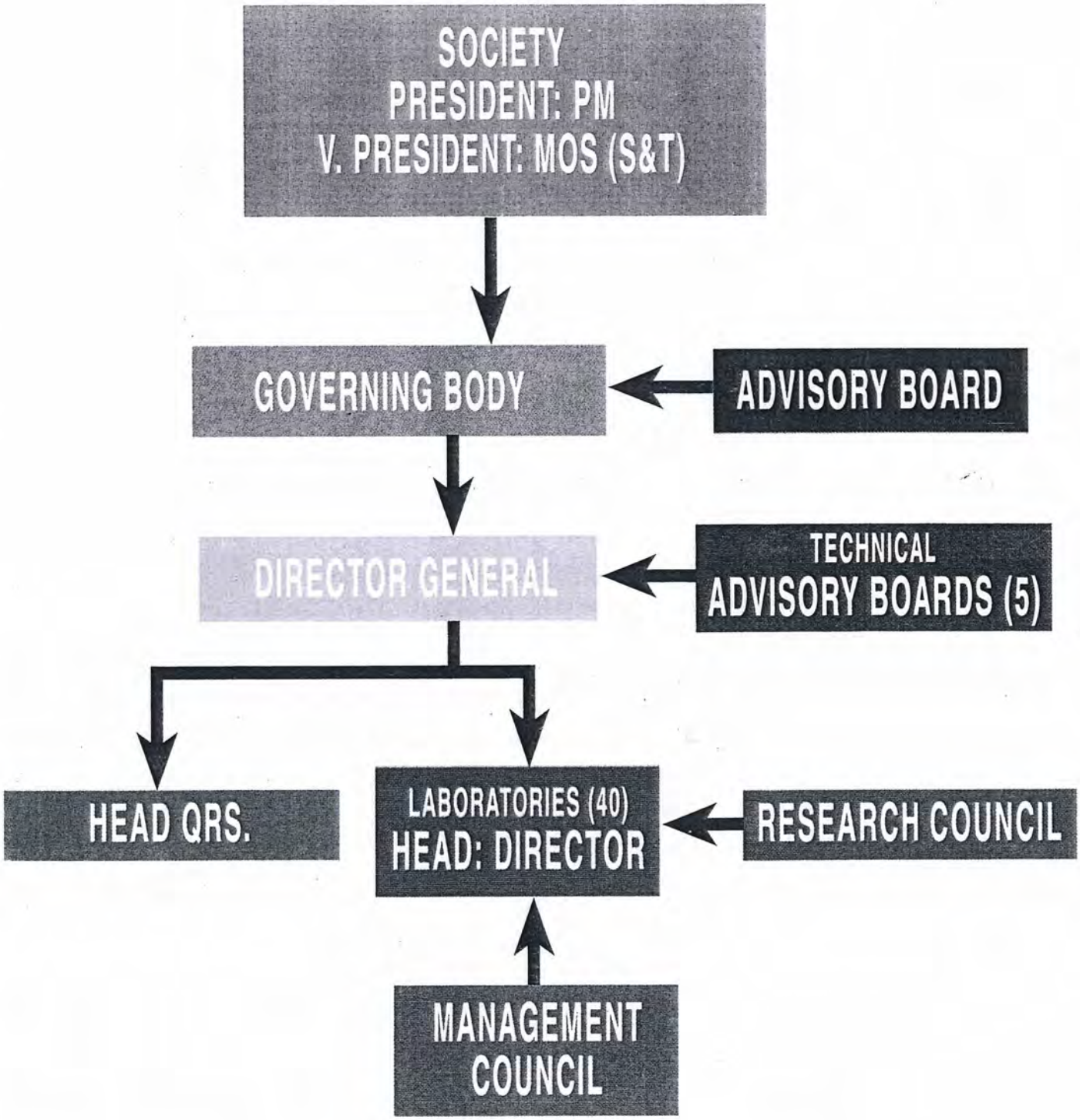
ORGANISATIONAL STRUCTURE



PRESIDENT:	SHRI P.V. NARASIMHA RAO
VICE-PRESIDENT:	SHRI BHUVANESH CHATURVEDI
DIRECTOR GENERAL:	DR. S.K. JOSHI (UPTO 30.6.95 FN)
	DR. R.A. MASHELKAR (W.E.F. 30.6 95 AN)

■ ESTABLISHMENTS

Central Building Research Institute **(CBRI)**, Roorkee-247667
Centre for Biochemical Technology **(CBT)**, Delhi-110007
Centre for Cellular & Molecular Biology **(CCMB)**, Hyderabad-500007
Central Drug Research Institute **(CDRI)**, Lucknow-226001
Central Electrochemical Research Institute **(CECRI)**, Karaikudi-623006
Central Electronics Engineering Research Institute **(CEERI)**, Pilani-333031
Central Fuel Research Institute **(CFRI)**, Dhanbad-828108
Central Food Technological Research Institute **(CFTRI)**, Mysore-570013
Central Glass & Ceramic Research Institute **(CGCRI)**, Calcutta-700032
Central Institute of Medicinal & Aromatic Plants **(CIMAP)**, Lucknow-226015
Central Leather Research Institute **(CLRI)**, Madras-600020
Central Mechanical Engg. Research Institute **(CMERI)**, Durgapur-713209
Central Mining Research Institute **(CMRI)**, Dhanbad-826001
Central Road Research Institute **(CRRI)**, New Delhi-110020
Central Scientific Instruments Organisation **(CSIO)**, Chandigarh-160020
CSIR Centre for Mathematical Modelling & Computer Simulation **(C-MMACS)**, Bangalore-560037
CSIR Palampur Complex **(CSIR,PLX)**, Palampur-176061
Central Salt & Marine Chemicals Research Institute **(CSMCRI)**, Bhavnagar -364002
Indian Institute of Chemical Biology **(IICB)**, Calcutta-700032
Indian Institute of Chemical Technology **(IICT)**, Hyderabad-500007
Indian Institute of Petroleum **(IIP)**, Dehradun-248005
Indian National Scientific Documentation Centre **(INSDOC)**, New Delhi-110067
Institute of Microbial Technology **(IMT)**, Chandigarh-160014
Industrial Toxicology Research Centre **(ITRC)**, Lucknow-226001
National Aerospace Laboratories **(NAL)**, Bangalore-560017
National Botanical Research Institute **(NBRI)**, Lucknow-226001
National Chemical Laboratory **(NCL)**, Pune-411008
National Environmental Engineering Research Institute **(NEERI)**, Nagpur-440020
National Geophysical Research Institute **(NGRI)**, Hyderabad-500007
National Institute of Oceanography **(NIO)**, Goa-403004
National Instt. of Science Technology & Development Studies **(NISTADS)**, New Delhi-110020
National Metallurgical Laboratory **(NML)**, Jamshedpur-831007
National Physical Laboratory **(NPL)**, New Delhi-110020
Publications and Information Directorate **(PID)**, New Delhi-110020
Regional Research Laboratory **(RRL,BHO)**, Bhopal-462026
Regional Research Laboratory **(RRL,BHU)**, Bhubaneswar-751013
Regional Research Laboratory **(RRL,JM)**, Jammu-Tawi-180001
Regional Research Laboratory **(RRL,JT)**, Jorhat-785006
Regional Research Laboratory **(RRL,TVM)**, Thiruvananthapuram-695019
Structural Engineering Research Centre **(SERC,G)**, Ghaziabad-201001
Structural Engineering Research Centre **(SERC,M)**, Madras-600113



■ OVERVIEW

The Performance

The year 1995-96 marked the fifth year of initiation of structural readjustment and change in the Indian industrial and trade sectors. The economy responded favourably to these measures and as a result 1995-96 witnessed a growth rate in GNP of over 7%, for the second successive year, and an unprecedented growth in industrial production of 12%. This success was reflected in CSIR's endeavours as well. External cash inflow into CSIR reached an all time high of Rs. 177 crore and the laboratory reserves increased to Rs. 42 crore (up from Rs. 147 crore and Rs. 28 crore respectively in 1994-95), technologies generated nearly doubled during the year as compared to the previous year and so did foreign patents filing.

CSIR 2001: Vision & Strategy

The encouraging performance emboldened CSIR to attempt charting out an agenda for the future. As a first step in this direction in August 1995 a base paper "Realising our Potential: The New CSIR" was prepared for the consideration of CSIR Advisory Board. Based on the wise counsel and mature inputs of the Advisory Board the base paper was revised and its elements and the approach to realise the potential were presented to the CSIR Society in its meeting held in August 1995. The Society endorsed the strategy and approach. Accordingly, a White Paper **CSIR 2001: Vision & Strategy** was prepared and discussed at a joint meeting of the Advisory Board and Directors of CSIR laboratories held in September 1995. The outcome was a wide-ranging consensus and commitment to the mission, vision, strategy and road map



outlined in the White Paper. Arising from this the CSIR announced an Intellectual Property Management Policy in October 1995 which was followed up by the release of the entire White Paper, CSIR 2001 : Vision & Strategy (full text at Annexure II) in January 1996.

A welcome initiative of CSIR was the enunciation, after more than 50 years of its formation, of its mission statement that seeks:

> ***"To provide scientific industrial research and development that maximises the economic, environmental and societal benefit for the people of India".***

The successful past performance and its complement of highly qualified scientific and technical personnel had emboldened CSIR to set for itself ambitious quantifiable goals to be achieved by the year 2001. These goals are to:

- **move towards the path of self financing by generating over Rs.7 billion from external sources, as against Rs.1.35 billion in 1994-95, of which atleast 50% will be from industrial customers (up from 15% in 1994-95);**
- **develop at least ten exclusive and globally competitive technologies in niche areas;**
- **hold a patent bank of 500 foreign patents (up from < 50);**
- **realize 10% of operational expenditure from intellectual property licensing (up from < 1%); and**
- **derive annual earnings of $ 40 million from overseas R&D work and services (up from < $ 2 million).**

The White Paper was widely circulated internally and externally to diverse constituents and sectors and covered by the media as well. The clarity of purpose and goals set in the White Paper received universal support and appreciation.

Technology Showcase '95, Singapore



In pursuance of the initiative mounted by the Hon'ble Prime Minister of India with the Hon'ble Prime Minister of Singapore for forging closer linkages in commercialisation of Indian/CSIR technologies in the SE Asia Region, CSIR supported by DST participated in a major Singaporean technological exposition – Technology Showcase '95 and International Conference on Technological Opportunities for the 21st Century.

The large Indian/CSIR pavilion was designed and fabricated in India and assembled in Singapore. On display were selected CSIR and CDAC and CMC technologies and capabilities relevant to the SE Asian Region in Biotechnology, Chemicals, Environment, Food and Information sectors. A special feature was the seminar on Technology Opportunities from India organised by the NSTB, Singapore on the occasion. The outcome of the participation was not



Indian/CSIR Pavilion at Technology Showcase '95, Singapore

merely useful contacts established and enquiries generated but also signing of four MOUs/LOIs for CSIR technologies.

Strategic Alliances

The HQs. actively canvassed for and catalysed forging of four MOUs for alliances with overarching all India financial institutions and industry associations namely the Industrial Credit and Investment Corporation of India (ICICI), Small Industry Development Bank of India (SIDBI), Confederation of Indian Industry (CII), Federation of Indian Chamber of Commerce and Industry (FICCI).

The alliances seek to synergise the core competencies of each partner to mutual advantage. The specific MOUs envisage:

ICICI - CSIR

i. Facilitating CSIR staff to acquire hands-on experience in industrial project preparation and appraisal;

ii. Devising innovative mechanisms and instruments for mobilising financial resources;

iii. Nomination of CSIR experts on Board of Directors of CSIR assisted companies.



SIDBI - CSIR

i. Evolving and offering SMEs viable technology cum financial packages;

ii. Assisting SMEs in their efforts to upgrade and modernise technology.

CII - CSIR

i. Spearheading IPR cause;

ii. Promoting the commercialisation and management of technology.

FICCI - CSIR

i. Facilitating joint R&D programmes;

ii. Utilising CSIR expertise for technology evaluation and upgradation;

iii. Involving CSIR experts in business delegations.

Restructuring of HQs.

Recognising that the HQs. had to function as a pro-active nerve centre for the realisation of the ambitious goals set for the year 2001, external consultants were appointed to help CSIR to study and devise the new role, functions and structure of the HQs. Arising from the study carried out by the consultants and wide ranging inhouse consultations, the technical divisions in the HQs. namely, the Planning Division, the Technology Utilisation Division, the Patent Unit and the International Scientific Collaboration Division were restructured as:

R&D Planning and Business Development Division

To symbiotically and synergistically link the planning process with the utilisation of the R&D outputs.

Intellectual Property Management Division

To formally recognise and bring to centre-stage the role of intellectual property in the CSIR and the leadership role that CSIR had played nationally.

International Scientific & Technology Affairs Directorate

In conformity with the opening up of the Indian economy to enhance foreign collaborations, alliances and business necessary for CSIR to emerge as a global R&D platform.



Societal and Technology Missions Division

In recognition of the potential and obligation of CSIR to provide S&T solutions/ inputs for national, societal and technological missions.

The restructuring has enabled functional integration and cross linkages significantly.

This report outlines the most significant of some of these contributions to the economy and to advancement of S&T knowledgebase and the activities of the Headquarters.

RESOURCE BASE

Infrastructural

		Number
❑ Laboratories/Institutes	40	(40)*
❑ Extension/Field/Regional/ Polytechnology Transfer Centres	80	(80)

Human

Total Staff	22,420	(23,350)
❑ Total S&T Staff	17,570	(18,300)
• Scientists (Group IV)	5,550	(5,750)
• Technical (Group III)	3,700	(3,800)
• Technical (Group V+II+I)	8,320	(8,750)
❑ Total Administrative & Non-technical	4,850	(5,050)

Financial

		Rs. Crore
❑ Government plan allocation	160.0	(141.4)
❑ Government non-plan allocation	251.7	(215.0)
❑ Extra budgetary resource generation		
• From Contract R&D and Consultancy	167.0	(137.2)
• Miscellaneous receipts (non-R&D)	19.1	(13.6)
• Laboratory reserves	42.1	(28.5)

*Figures parenthesized correspond to the previous year 1994-95



PERFORMANCE IN 1995-96

Contribution to Economy

		Rs. Crore
❑ Industrial production based on CSIR Knowhow	3,000	(2,600)*
❑ Saving in productivity accruing through CSIR R&D efforts	210	(200)

Science Output

		Numbers
❑ Papers Contributed	2,859	(2,840)
❑ Patents	318	(269)
• Filed in India	260	(241)
• Filed abroad	58	(28)
• In force in India	515	(414)
• In force abroad	75	(51)

Technological Output

		Numbers
❑ New Knowhow Licensed	46	(50)
❑ Licensing Agreements Executed	190	(187)

External S&T Human Resource Development

		Numbers
❑ Research Fellows/Associates supported	6134	(5,000)
❑ Emeritus Scientists in position	143	(134)
❑ Pool Scientists (SRAs) in position	428	(453)
❑ Research Schemes supported	542	(695)

Resource Mobilisation

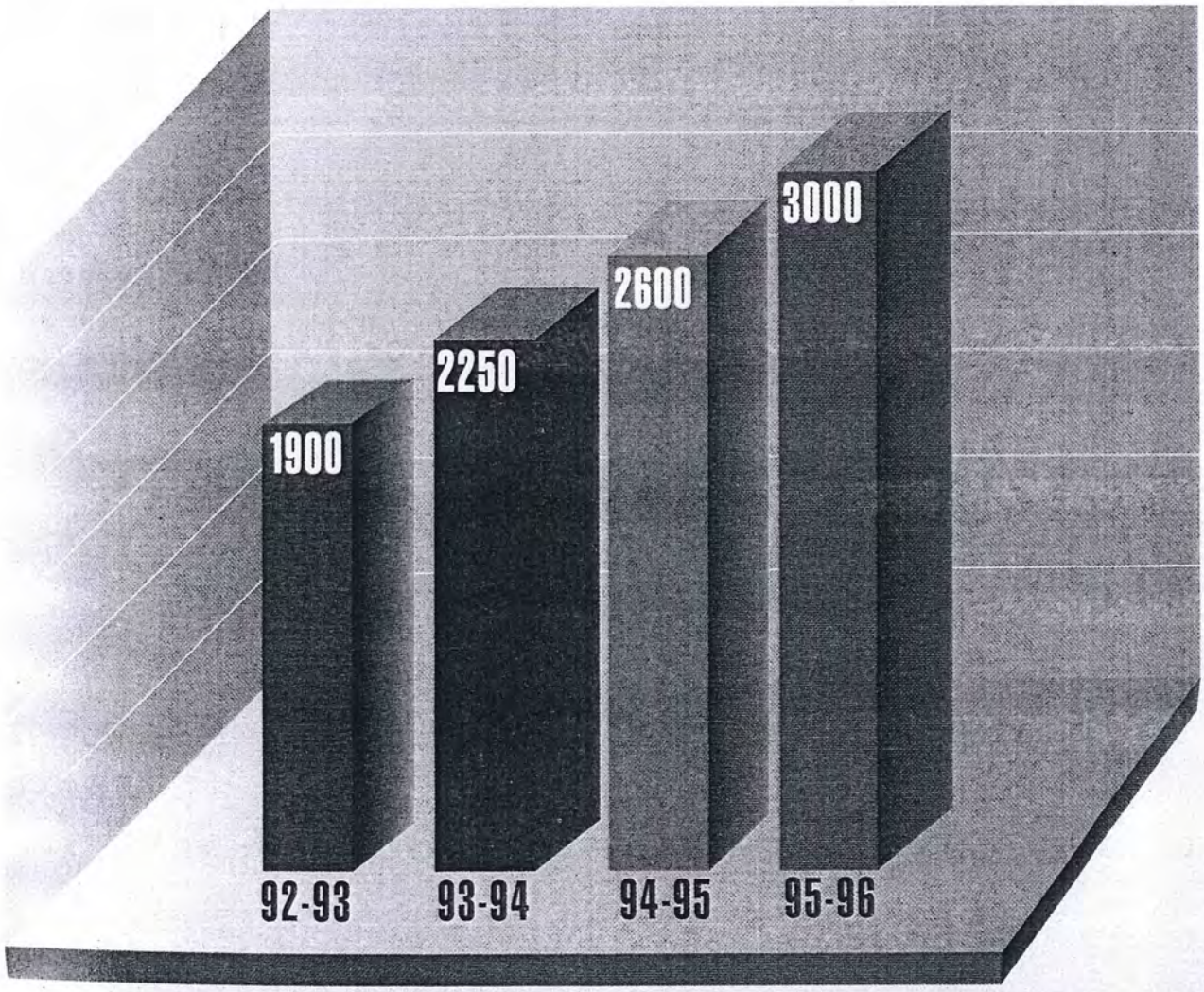
		Rs. Crore
❑ External Cash Inflow total	177	(147)
❑ Contract value of projects on hand		
• Contract Research	265	(230)
• Consultancy	45	(35)

*Figures parenthesized correspond to the previous year 1994-95



ANNUAL INDUSTRIAL PRODUCTION BASED ON CSIR KNOWHOW

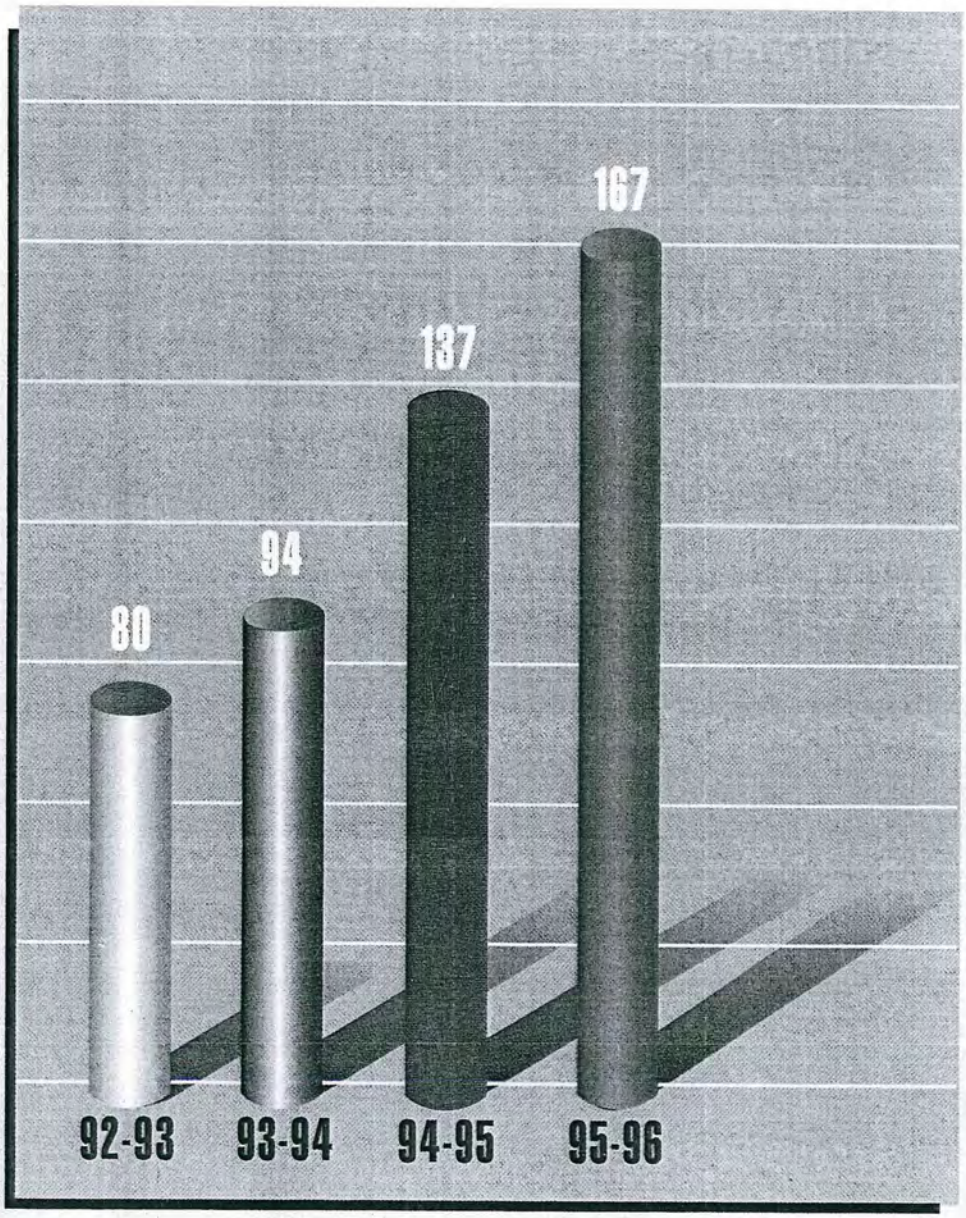
(Rs. Crore)



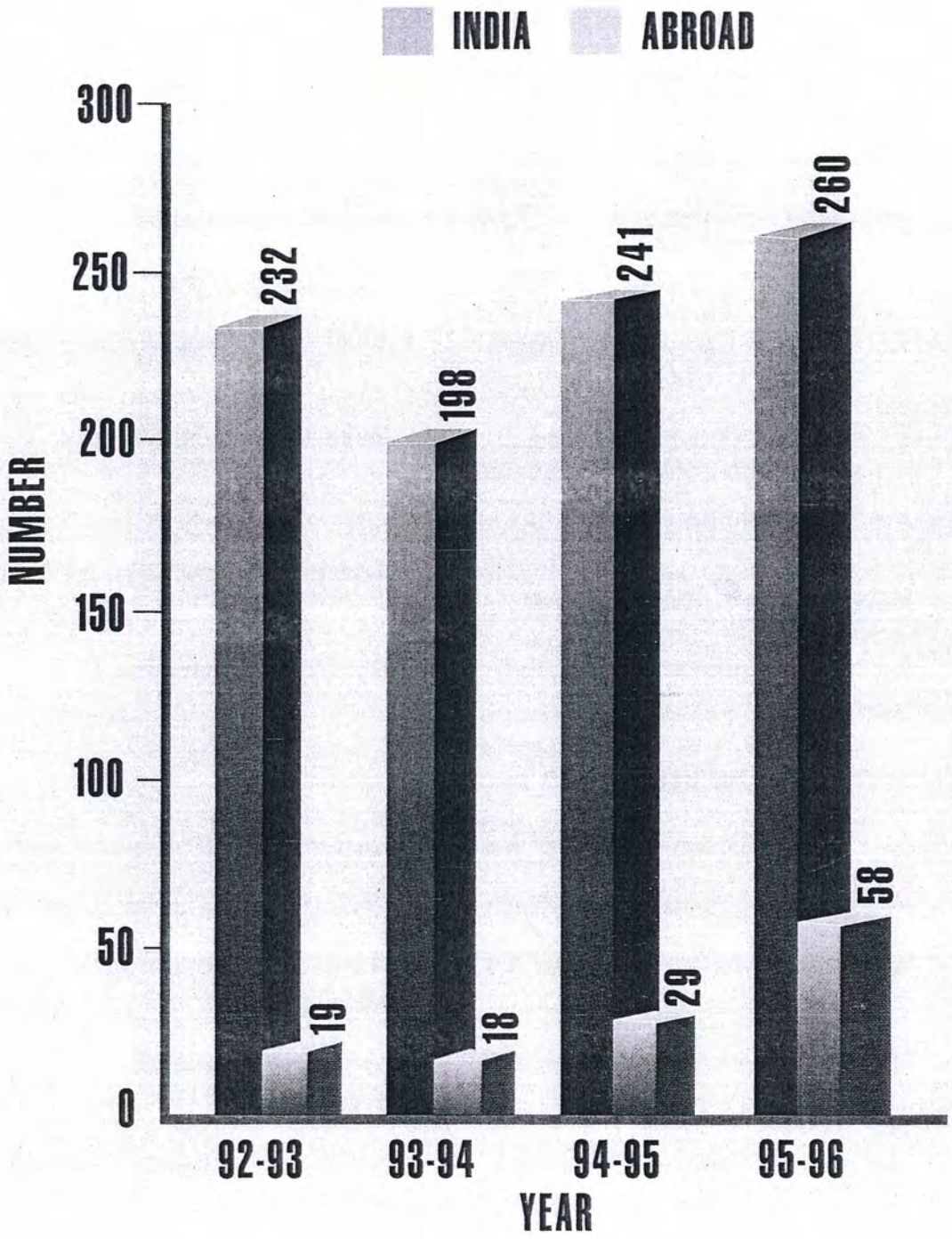
EXTERNAL CASH INFLOW

Contract R&D and Consultancy

(Rs. Crore)



PATENTS FILED



KNOWHOW LICENSED FOR THE FIRST TIME

KNOWHOW / TECHNOLOGY	LICENSEE
• BIOTECHNOLOGY	
1. Bovine serum albumin **(CBT)**	Ashian Bioford P. Ltd., Noida
2. Nursery technology **(NBRI)**	UPLDC, Lucknow
• CHEMICALS AND ALLIED PRODUCTS	
3. Di methyl tetrazole chloride (DMTrCl) and 1-hydrogen-tetrazole **(CBT)**	Argosy Overseas Ltd., Lucknow
4. Kala-Azar diagnostic kit **(CDRI)**	Span Diagnostic Ltd., Surat
5. Leuprolide acetate **(CDRI)**	Cipla Ltd., Bombay
6. Platinum plating concentrate solution **(CECRI)**	Premal Consultants P. Ltd., Pune
7. Polymer cement coating system for corrosion prevention **(CECRI)**	Devika Chemicals, Bombay
8. Plaster of paris from phosphogypsum **(CGCRI)**	Sujata Enterprises, Kurnool (A.P.)
9. Sol-gel application of anti-reflective coatings on opthalmic and other circular lenses **(CGCRI)**	BEL, Jaloji (Maharashtra)
10. Polyester based sealant **(CGCRI)**	Concept Chemical Works, Calcutta
11. Reethagal shampoo **(IICT)**	Sodhan Product, Hyderabad
12. 12-hydroxy stearic acid **(IICT)**	Sunrise Oleochemicals Ltd., Hyderabad
13. 3,4,5 trimethoxy benzaldehyde **(IICT)**	Jupitor Organics Ltd., Secunderabad
14. Acephate (Tech) **(IICT)**	Lupin Agro Industries (I) Ltd., Bombay
15. Hexane using NMP as solvent for extraction **(IIP)**	BPCL, Bombay
16. Hydrogenation of PAO **(IIP)**	Lubrizol India Ltd.



KNOWHOW / TECHNOLOGY	LICENSEE
17. Sulpholane extraction for BTX production **(IIP)**	NOCIL, Bombay
18. Naphtha hydrodesulphurisation **(IIP)**	BPCL, Bombay
19. Acrylamide-2-methyl propane sulphonic acid (AMPs) **(NCL)**	Adarsh Chemicals & Fertilizers Ltd., Surat
20. Hydroquinone/catechol **(NCL)**	Asian Peroxide Ltd.
21. Corrosion and scale inhibitor (CORISCA-95) **(NML)**	Kesal Chemical, Calcutta
22. Leachable MnO from pyrolusite **(RRL,Bho)**	Bharat Zinc, Bhopal
• DRUGS & PHARMACEUTICALS	
23. Cisapride **(IICT)**	Torrent Laboratories Ltd., Bombay
• FOODS & BEVERAGES	
24. Cumin oil **(CFTRI)**	Khyati Oil & Agro Industries P. Ltd., Unjha
25. Curing of cocoa beans **(CFTRI)**	Padival Agro Agencies, Puttur
26. Papaya/Carrot tuity fruity **(CFTRI)**	1. Jayalakshmi, Kerala 2. Shyamratna Enterprises, Dharwad
27. Supplementary nutritive food **(CFTRI)**	Karnataka Food Products, Gulberga
28. Dehydration of Oyster mushroom **(CFTRI)**	Growtech Agro (I) P. Ltd., Hyderabad
29. Chicken Wafers **(CFTRI)**	Rajashree Prashant Hinge, Nagpur
• BUILDING MATERIALS	
30. Fire resistant metallic door **(CBRI)**	Abaqs Building Systems P. Ltd., Bombay
31. Expanded polystyrene composite door shutter **(CBRI)**	Kutty Flush Doors & Furniture Co. P. Ltd., Madras



KNOWHOW / TECHNOLOGY	*LICENSEE*
32. Epoxy/phenolic Inter Penetrating Network-(IPN) Reinforced based system for the protection of steel reinforcement in concrete **(CBRI)**	Krishna Conchem Products, Bombay
33. Galvanised rebar for reinforced concrete corrosion **(CECRI)**	Indian Lead Zinc Information Centre, New Delhi
34. Ceiling boards from agrowaste and other cellulosic material **(IICT)**	Sunrise Board, Jorhat
35. Acoustic Tiles **(IICT)**	Minwool Rock Fibres Ltd., Hyderabad
36. R-wood products from industrial wastes **(RRL,Bho)**	Dual & Visual Co., Madras
• ELECTRONICS & INSTRUMENTATION	
37. Supervisory Control and Data Acquisition System (SCADA) **(CECRI)**	IOC, Madras
38. Door scope **(CSIO)**	Irusha India, Chandigarh
39. LPG Sensors **(IICT)**	Panam Controls, Secunderabad
• METALS & ALLOYS	
40. Platinised titanium anodes by electrodeposition **(CECRI)**	Premal Consultants P. Ltd., Pune
41. 75% Fe-Si **(NML)**	Bhutan Ferro Alloys Ltd., Bhutan
42. High purity iron oxide **(RRL,Bhu)**	Rungta Mines P. Ltd., Bihar
43. Beneficiation of sillimanite using flotation column **(RRL,Bhu)**	IRE, Bombay
• OTHERS	
44. Fire protection layer for aircraft seat cushions **(CBRI)**	Signum Fire Protection (I) P. Ltd. Bombay
45. Cable fire barrier **(CBRI)**	Signum Fire Protection (I) P. Ltd. Bombay
46. Impregnating pitches **(IIP)**	Graphite India Ltd., Bangalore



■ CONTRIBUTIONS TO SOCIO ECONOMIC SECTORS

AEROSPACE

NAL has been rendering yeoman service to the Indian aerospace sector through its high quality manpower, who are acknowledged not only nationally but internationally, as well as its excellent infrastructural support facilities such as the National Trisonic Aerodynamic Test Facilities (NTAF), Acoustic Test Facilities (ATF) and full scale fatigue testing of aircraft. During the year NAL generated an unprecedented all time high external cashflow of nearly Rs. 44 crore which was 150% of the direct government grant to it from the CSIR, thus reflecting the excellent linkages and rapport it has built up with its potential customers. During the year NAL's output encompassed not only services and technology but high quality science as well.

Science



Direct Simulation of Turbulent Flow

Unsteady three dimensional turbulent flow, important in the design of aircraft wings and other industrial structures, was simulated by NAL using the Navier-Stokes equations with low Reynolds numbers. Such simulation normally requires very powerful computers but with the model developed, modest computing facilities at NAL were used and yielded results comparable to the best available in the world for this class of problems. This work has led to research in the area of Large Eddy Simulation (LES), for application in three dimensional wing design and also has the potential of application in industry being applied for predicting realistic flows.

Fluid Instability and Transition

A stability theory for spatially developing flows was proposed by NAL to account for the non-parallel nature of the flows in boundary layers over flat plates. It was shown that non-parallel effects (surprisingly) appear at a lower order than 1/R (where R is the boundary layer Reynolds number) and a lower order stability equation was derived and shown to contain most non-parallel effects. As a derivative of this research an industrial code useful in the design of laminar airfoils has been developed. The e^n method has been used in this code which not only predicts the extent of laminar flow to be expected but it can also be used to eliminate excess acceleration upstream in order to minimise downstream pressure recovery.

Finite Element (FE) Package with Expert System Advisor and Control

NAL was able to make a significant breakthrough in FE literature by the: (i) introduction of the variational correctness principle and its axiomatisation from the Hu-Washizu principle; (ii) establishment of the stress correspondence paradigm as the basis for the working of the finite element process (and not the displacement correspondence paradigm as has been assumed so far in the literature; and (iii) axiomatisation of this from the same Hu-Washizu principle. These principles were used to incorporate thermal stress analysis capabilities to the existing static, dynamic and instability capabilities for beam and plate elements based on the Lo-Christensen-Wu higher order theory. Design of non-linear finite elements is being taken up based on these principles. Software based on aforesaid developments has been licensed to five organisations.

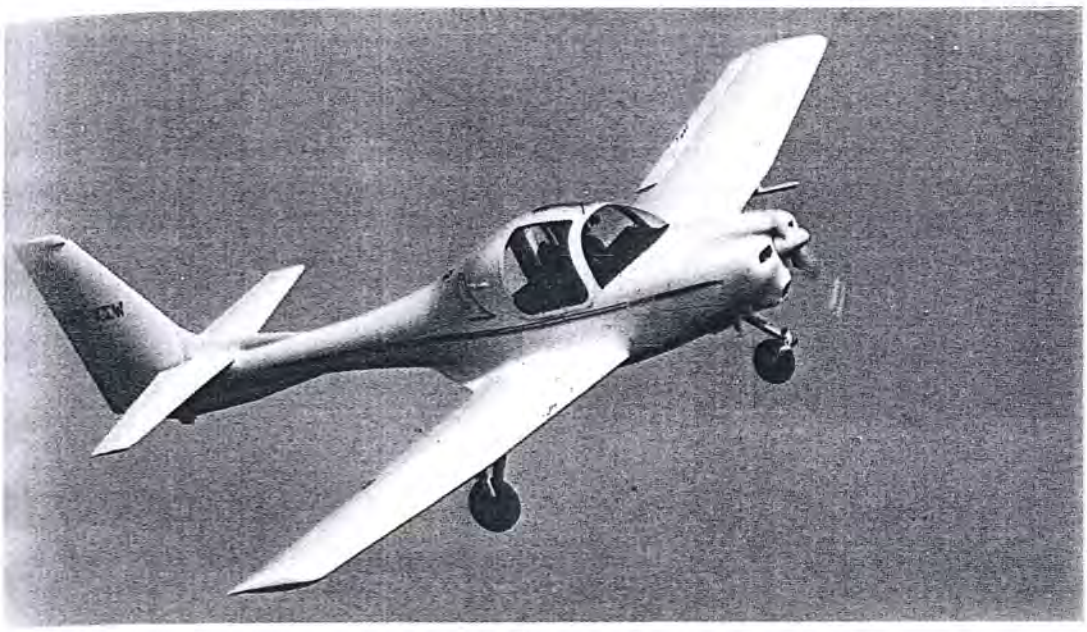
Stress Analysis by X-ray diffraction

The presence of stresses (residual or applied) in polycrystalline specimen causes a shift of the x-ray diffraction line which makes it possible to calculate the stress in the specimen from the measurement of the shift. This conversion of the measured shift of diffraction line to stress requires use of an appropriate function containing elastic constants. Since the crystallites present in the specimen are elastically anisotropic, the elastic constants are represented by a fourth rank tensor. The calculations are further complicated by the fact that x-ray diffraction introduces a strong selectivity, implying that the crystallites of all possible orientations do not contribute to diffracted intensity at the point of observations. Exhaustive work done at NAL over the last 25 years has enabled it to develop expertise to measure such stresses and it offers this as a service to customers.



Re-engining and Test Flying of HANSA 2 RE

The HANSA series of all composite light aircraft is ideal for ab initio training, sports, hobby flying, surveillance, aerial photography and environment monitoring as well. The HANSA series of aircraft have been designed and



Hansa-2RE in Flight

developed by NAL, in association with Taneja Aerospace and Aviation Limited (TAAL). The first version of HANSA 2 has been flying for over two years. One of the limitations found in the aircraft performance was the relatively poor climb rate. To correct this the 100 BHP engine was replaced by Teledyne IO-240, 125 BHP engine. The re-engined version HANSA-2RE was test flown in January 1996. The new engine is a fuel efficient engine and its acceleration qualities are very good as well.

Support to LCA Programme

i. **LCA Fin and Rudder :** NAL handed over the co-cured, co-bonded composite fin and rudder of the LCA to ADA in September 1995. This development signified a major step towards achieving self-reliance in strategic technologies. Both the fin and rudder have been developed according to specially formulated quality procedures using co-curing fabrication technology which has facilitated effective consolidation of parts, there being only 7 major parts. Also, a new method was developed to carry out non-destructive evaluation of co-cured components using through transmission squirter type ultrasonic C-scan system.



The rudder designed by HAL (ADB) was fabricated by NAL using composite tools. It comprises of integral rib-skin construction for inter spar box (ISB) and has a sandwich aft box. The ISB has been produced as a single jointless co-cured unit using composite tooling with inflatable rubber mandrills. Specially designed composite moulds have been used for skin-core bonding of the sandwich aft box. The fin and rudder were assembled on in-house developed jigs and fixtures.

ii. **LCA CFC wings :** The first set of CFC wings for use on the LCA were delivered to HAL/ADA by NAL in October 1995. The wings were subjected to ground vibration testing and their performance was found to be close to

theoretical predictions. It is expected that NAL will complete the task of delivering 3.5 sets of CFC wings for LCA by March 1997.

iii. LCA Control Law : The performance (manoeuvrability, control etc.) of a fighter aircraft largely depend on the quality of the flight control software available on the aircraft's on-board computer. As part of the National Control Law team for LCA, NAL undertook digital control law development and design for the LCA TD 1 and TD 2 versions. Substantial progress was made on refining the control laws, through extensive off line and real time simulation studies. Inflight simulation was carried out on the USAF NT-33A Variable Stability Research Aircraft at USAF base at Niagara Falls. The results from each flight evaluation were analysed to refine the control law.

Portable Flight Data Readout System

A portable UFDR (Universal Flight Data Recorder) developed by NAL enables direct data acquisition from the DFDR and thus eliminates the need for cumbersome hardware interface for the readout facility or the removal of the DFDR from the aircraft. The system is built around a laptop PC and uses special circuitry to convert Harvard bi phase data to parallel form. The UFDR approved by the Director General, Civil Aviation (DGCA) incorporates a fully menu driven data acquisition software which can perform all requisite functions such as track increment, fast forward, rewind etc. Developed basically to cater to the requirements of air taxi operators in the country, the system software has been extended for the Airbus A-320 aircraft as well.

Advanced Light Helicopter (ALH) Shake Test Facility

A dedicated shake test facility developed at NAL was delivered to HAL for ground resonance testing of helicopters of their Advanced Light Helicopter



ALH Shake Test Facility



(ALH) series. The state of the art computer controlled multi input output (MIMO) test facility incorporates specially developed user friendly application software interface to graphically depict the helicopter's vibration characteristics.

This comprehensive system, ideal for structural dynamic testing of other complex structures like aircrafts and automobiles as well, was developed in record time of three years.

Services

Fabrication of Bimetallic Rings

A 400 mm bimetallic ring of copper and silver without overlap or use of filler material for joining was successfully fabricated (after electroforming and machining) and handed over to TIFR in August 1995. This is the first ring of its kind in the world and its fabrication involved precision electroforming method which posed several scientific-technological challenges.

Raj Mahindra Computer Aided Design Facility

The Raj Mahindra CAD Facility, established at NAL is a well balanced computer system with PCs, workstations and number of high quality devices to aid design, drafting, and development work.

The major drafting facility consists of 12 Intel 486 based PC ATs connected through a thin ethernet network for resources sharing. The facility essentially uses the Auto Desk Auto CAD Rel 12 package, with an advanced modelling extension to carry out basic 3D operations and an AutoCAD designer and the AutoCAD data extension module to manage drawing files efficiently.

For the high end CAD solution of designing aircraft components, the Centre has a carefully formulated match of RS 6000 workstations from IBM, and CATIA by Dassault, which is now the de facto standard in the aircraft industry for CAD solutions. The CATIA modules include a wide range of functionalities from basic wire frame modelling to NC tool path generation, interface to other packages for analysis and a host of other capabilities. The overall hardware components have been networked through a 16 port unmanaged hub. The facility was commissioned in August 1995.



Radome for Doppler Weather Radar

ISTRAC of ISRO has in principle accepted the NAL proposal for the design, fabrication, testing and installation of a 14 m diameter FRP-foam sandwich panelled radome to cover the S-band Doppler weather radars being developed by ISTRAC. For this purpose a preliminary design of the radome was carried out. The radome will be made out of several rigid PU-foam FRP sandwich flat panels of triangular geometry. The radome is designed to withstand gust wind speeds of 300 kmph.

Supersolver

The Supersolver is the fourth in the Flosolver series. In conforming with the philosophy of Flosolvers to use, off-the-shelf components, MIPS R8000 based single board computers from Silicon Graphics were acquired and the communication board was adapted from a product already available with Tata Elxsi, NAL's partner in the development of Supersolver. It has four R8000 processors and peak processing power of 1.2 GFLOPS. The effective power of the new machine can be judged from the fact that to run GCMT 80 code, for a 24 hour weather forecast the earlier five processors Mk3 took 100 minutes and a single R8000 processor about 55 minutes as against the Supersolver speed of 8 minutes.

Human Resource Development

Advanced Information Technology Centre (AITC)

The Advanced Information Technology Centre to cater to training of personnel in the areas of geographic information system (GIS), CAD/CAM, virtual reality, animation, database management applications, multimedia applications and mathematical modelling and advanced computer simulation, was initiated at NAL under the CTD/USAID programme in 1994. The Centre is equipped with the latest state of the art technology (hardware and software) and has a dedicated teaching faculty. Several training programmes in all the areas mentioned above have been documented for personnel from industries, R&D organizations, university faculties, government departments and CSIR labs. Software development in the area of GIS and CAD are on the anvil.

Apart from these, a 486 based SCO Unix server with several VT 100 and X terminals will cater to the needs of design, aerodynamics and structural calculations. A number of 486 based PC ATs have also been earmarked for text and graphic processing and other DTP applications so that a high quality of design documentation and presentation material is ensured.

The output devices consist of two A0 size direct imagining plotters from Calcomp, a high quality pen plotter from Graphtech, an A3/A4 size laser plotter, an A3/A4 size Calcomp colour printer and a large number of 9 and 24 pin dot matrix printers. All these printing devices will be shared on a local area network basis.



Recognitions & Awards

CSIR Technology Shield for Engineering Technology	• National Aerospace Laboratories, Bangalore
Fellow of Royal Society of Chemistry London	• Dr. Indira Rajagopal, NAL
Member of New York Academy of Sciences	• Dr. K.S. Rajam, NAL

BIOLOGY AND BIOTECHNOLOGY

Application of biology and biotechnology made rapid strides the world over and its impact was felt in pharmaceuticals, diagnostics, fermentation products and in bioprocessing and agro & forest areas. However the rather nascent nature of biotechnology industry in India limited the realisation of the full potential of the R&D capabilities and in a sense influenced the pace and nature of R&D as well. Nonetheless, judging from the immense potential biotechnology holds for changing the style and quality of life in the years to come, CSIR has built up commendable capabilities and facilities in this area that would help to usher in India the biotechnology revolution with all its benefits.

Two CSIR laboratories namely, CBT and IMT are primarily engaged in R&D for the biotechnology sector, whilst R&D work related to modern biology, cellular and molecular biology, plant molecular biology and medical biology is being carried out at CCMB, CDRI, CFTRI, IICB, ITRC, NBRI, CIMAP, RRL-Jm. and CSIR Complex, Palampur. Another four laboratories that contribute R&D of relevance to this sector are CLRI, CSMCRI, IICT and NCL.

Science

Ionic Interactions in the DNA Duplex and Triplex Effect on Thermal Stability

Interactions among ions, water molecules and DNA are highly specific in nature and can be treated as potential forces responsible for thermal stability of the DNA duplexes. Thermal stability, indicated by the melting temperature, Tm at which a DNA duplex converts into two single complementary strands, varies with the changes in base composition, base stacking and ionic environment. The stability of DNA duplex was studied at NCL by means of the measure of electrostriction effect – internal pressure to yield simple though impressive correlations with the Tm values of the DNA duplexes with different base pairs and compositions. Internal pressure was used to interpret the thermal stability of the DNA duplexes in the ionic solutions at different concentrations. Simple but striking correlations have been observed for a DNA duplex, at a fixed ionic concentrations of several salts. The correlations can prove to be very powerful tools to quantify the stability of the DNA duplexes being used in antisense technology, where accurate correlation between the thermal stability of several PNA-DNA duplexes is required for drug designing.



Cataract and Other Eye Diseases

CCMB continued its molecular epidemiology studies on cataract of the eye lens and the molecular interactions in cornea that govern its transparency. CCMB undertook studies on the structural role of the two major

proteoglycans, keratan sulfate proteoglycan (KSPG) and dermatan sulfate proteoglycan (DSPG), that constitute the cornea. It was seen that KSPG is an "ambidextran" which is able to effectively interact with collagen (the other major component of the cornea) on one hand and with lipid vesicles on the other thereby suggesting that KSPG plays the role of a "filler" substance in the extracellular matrix of the cornea. The other major soluble protein of the cornea, aldehyde dehydrogenase or ALDH was seen to display two interesting properties that are of protective value to the tissue – one, its ability to act as an antioxidant, and the other, its relatively higher ability to withstand photo stress – both of which seem attributed to the presence of accessible *cys* residues in the molecule.

The studies on the role of molecular chaperones in protein folding, assembly and stability – the biophysical challenge of recent years have shown that α-crystallin under appropriate conditions offers a hydrophobic surface that binds to incorrectly folded substrate proteins (e.g. insulin, β-crystallin) and inhibits their self-aggression and insolubility. Results on rapid refolding of crystallins from relevant experiments also support the hypothesis that α-crystallin prevents aggregation of non-native structures by providing appropriately placed hydrophobic surfaces.

Immunomodulation by Liposomes

CBT has demonstrated that allergens incorporated in liposomes injected repeatedly in Balb C animals results in modulation of immune response leading to suppression of Th2 response and recruitment of Th1 cell. Cytokine profiles clearly indicated that IL4 secretion was reduced and r interferon levels were increased leading to decreased IgE synthesis and increased IgG synthesis. This immunomodulation protects the sensitized animals from anaphylaxis when challenged with the sensitizing allergens. This observation has been confirmed internationally and CBT is thus first to propose that liposomes will be good carriers of allergens for safe and effective immunotherapy.

Gene Expression using Spodoptera litura Nuclear Polyhedrosis Virus (SINPV)



Polyhedrin, the hyper active gene of baculovirus, SINPV (*S. litura* nuclear polyhedrosis virus) coding for the occlusion body protein of the virus has been characterised and sequenced by CBT. This is a new baculovirus isolate of Indian origin characterised by genomic analysis. It has a circular double stranded supercoiled DNA genome of 132 kb. Four transplacement vectors have been constructed to express the foreign genes under the polyhedrin promoter of SINPV in insect cells.

This is the first reported Indian isolate of baculovirus characterised and a patent application has been made for the transplacement vector constructs based on polyhedrin promoter of SINPV. These constructs can be utilised to express foreign genes abundantly in insect cells. In addition this virus is an

effective biopesticide for the polyphagous tobacco caterpillar, which has over hundred host plants including the commercial crops such as groundnut, cotton, tobacco, chilli.

Lectin as an Important Biochemical and Diagnostic Tool

CBT has identified and characterised a glucose specific lectin (Peanut Root Agglutinin, PRA II) from peanut (*Arachis hypogaea*) roots. The lectin oozes out from the cortical parenchymatous cells and remains anchored to the root surface. The carbohydrate binding site of the divalent PRA II remains free for binding with peanut specific rhizobia through their cell wall lipopolysaccharides (LPS). Highly specific interaction between legume roots of peanut and specific rhizobia which leads to modulation, is mediated through PRA II. The most potent inhibitor of PRA II is cell wall LPS of peanut specific rhizobia (68 fold higher than glucose) but not that of non specific rhizobia.

First step in multi step process that lead to nodulation in legumes is the recognition of specific rhizobia by the roots. This recognition process involves specific binding of nodulating rhizobia to roots. The appearance of PRA II in roots of emergence of peanut root hairs and the absence of PRA II in non nodulating variety of peanut confirms that host specificity is expressed prior to rhizobial interaction with the roots. Host rhizobium recognition process involves specific binding of peanut root surface lectin (PRA II) and cell wall lipopolysaccharides of peanut specific rhyzobia. These findings can be utilized to identify host specific rhizobia from soils using lectin as a tool.

Influence of Ultrasound on the Activity of Enzymes

The effect of ultrasound on enzymes, enzyme reactions and on immobilized enzymes in vitro and on enzyme formation and activity in vivo is of recent origin. Attention has been focused on studies for the use of ultrasonics for increasing the enzyme activity of the micro-organisms at RRL-Bhu.

Preliminary experiments conducted to reduce the protease production in tripchophylin rubrum using ultrasound showed that the enzyme activity of organism exposed to ultrasound on 5th and 7th day of inoculation was found to decrease by 70% and 30% as compared to control, which is an encouraging result.



Synthesis of Spiroannulated Dihydrofurans

A facile method for the synthesis of spiroannulated dihydrofurans has been developed at RRL-Tvm. by the cerium (IV) ammonium nitrate (CAN) mediated oxidative addition of 1,3-dicarbonyl compounds to terminal alkenes. Also a novel reaction of benzylic radicals and dioxigen has been discovered in the CAN mediated additions of diethylmalonate to styrenes.

Synthesis of Some Biologically Active Natural Product using Chemoenzymatic Techniques

The asymmetric synthesis of biologically active compounds, especially complex natural products is an extremely challenging task. Among the various methodologies that have been developed for enantioselective synthesis, the use of enzymes as chiral catalysts has attracted much attention. RRL-Tvm. has synthesised chiral intermediates useful in the elaboration of biologically active natural products belonging to the family of drimanes, labdanes, hopanes etc., using lipase catalysed acylation. The methodology is useful for the synthesis of chiral feedants and pheromones which are being used as pest control agents.

Lead Compounds for HIV

A new unprecedented spherical carbocyclic lactone has been isolated and characterised by RRL-Jt. from *Baccurea sapida* seeds. *B. sapida* is a plant of the family Euphorbiaceae and grows in the Brahmaputra valley. It may be noted that several plants from Euphorbiaceae family have yielded several anti HIV lead compounds. Also a new alkylated coumarin with close structural relationship with anti HIV lead compound 'Calanolide' has been isolated by RRL-Jt. from the plant *Kayea assamica*, a Guttifarae family plant occurring only in a particular district of Assam.

Mechanism of Benzene Toxicity

Study carried out by ITRC on benzene toxicity revealed that benzene 1,2,4 benzenetriol (BT) was found to release significant amount of iron from ferritin dependent on the concentration. The iron release from BT enhanced lipid peroxidation and also catalyzed the release of aldehydic products from bleomycin dependent degradation of DNA. Addition of BT to bone marrow cell lysate resulted in an increase of iron release as a function of time indicating that BT is a potent reductant of ferric iron of ferritin and also mobilizes and releases iron from ferritin core. The release of iron from bone marrow lysate by BT may assume toxicological significance as this could lead to disruption of intracellular iron homeostasis in bone marrow cells. The study thus offers new information that the iron released from ferritin by BT could affect maturation and differentiation of bone marrow cells resulting in bone marrow depression which is expressed in humans as well as experimental animals during benzene exposure.



Pulmonary Toxicity of Coal Fly Ash

Effect of intratracheally injected fly ash on the development of pulmonary and systemic immunity was studied in rats by ITRC. Following intratracheal and interperitoneal immunisation with sheep red blood cells (SRBC) there was an appearance of antibody forming cells (AFC) in lung associated lymph nodes (LALN) of animals exposed to either flyash or physiological saline. These results demonstrate that fly ash burden of lungs results in an

impairment of the local immune response of the lungs without an associated effect on the systemic immunity. The study shows that native and metal coated flyash, brings down the local immune response of lungs without affecting systemic immunity. The immunosupression appears to be due to the presence of the metallic constituents.

Heme Oxygenase in Sensitive Strains of Plasmodium Berghei

The possibility of making chloroquine resistant malarial parasite susceptible to chloroquine with the help of resistance reversal agent has been established by CDRI. Chloroquine-resistant (CQR) and – sensitive (CQS) *Plasmodium berghei* K173 strains possessed significant activities of heme oxygenase, biliverdin reductase and heme polymerase. The cause of resistance to chloroquine has been attributed to the overproduction of plasmodial heme oxygenase and high heme – polymerisation activities in resistant parasites. The study suggests the importance of heme oxygenase and related components in the biochemical regulation of malaria parasites and in understanding the mechanism of the acquisition of chloroquine resistance.

Technology

Production of Cellulose-free Xylanase

Biobleaching of cellulosic pulp in paper and viscose rayon manufacture is likely to replace the presently used chlorine atom method. Generally however high xylanase producer fungi are good cellulase producers as well . A proprietary strain of IICB *Termitomyces clypeatus* produces high xylanase and low cellulase, where the activity of the later enzyme has also been removed by a simple treatment. Upscaling of the process is being done jointly by IICB and IMTECH. A patent has been filed.

Chemical Synthesis of Gene Encoding HEGF

The gene coding human epidermal growth factor (HEGF) has been synthesised, cloned, sequenced and expressed in E-coli. The protein has been purified and shown to be biologically active. CBT has standardised the recombinant DNA technology and is exploring avenues for its commercialisation.



Chemical Synthesis and Assembly of Double Stranded DNA

There has been a continuous effort world wide to simplify the protocols and reduce the error rate for synthesis of DNA. The method developed at NBRI allows the synthesis and assembly of long double stranded DNA molecules, quickly, simply and efficiently. It consists of extending the double stranded DNA stepwise through polymerase chain reaction, with final amplification being done at high annealing temperatures. The method does not require ligation, extensive purification of oligonucleotides and does not

give wrongly amplified products in any significant amount. As the initial gene is derived from a plant the bio hazards are minimum and the method would be of value in custom synthesis of genes and expression elements of DNA.

Cyclosporin

An indigenous process employing solid state fermentation route using locally isolated strain of *Tolypocladium inflatum* was optimised at RRL-Tvm. with yields of 400 mg of cyclo-A/kg of wet substrate as compared with yields of only 35 mg cyclo-A/litre of substrate for submerged fermentation.

Processes for the Synthesis of 1H Tetrazole and 4,4 Dimethoxytrityl Chloride (DMTr Cl)

1-Tetrazole and DMTr CI are the key reagents used for oligonucleotide synthesis. The novel single step continuous process developed at CBT for the synthesis of DMTr Cl does not involve the use of expensive raw materials. The quality of the product prepared by this process has been found to be far superior to that available in international market. The technologies for both these products have been transferred to industry. The firm has sought design engineering assistance from NCL for designing a commercial size production unit.

Wild Life Conservation by DNA Finger Printing

For the first time ever, propagation of endangered wild life species by genetic fingerprinting of the individual animals to raise healthy offsprings from select parents chosen on the basis of their genetic endowments has been undertaken at CCMB. In a collaborative programme with the Central Zoo Authority of India, CCMB has worked on 250 blood samples from a range of animals viz. tigers, lions, leopards, elephants, wolf etc. for chromosome isolation and analysis for abnormalities and DNA fingerprinting. Protocols for experimental requirements like tranquilizing and capturing of animals, storage and transportation of samples etc. have been standardised. Analysing of semen samples of several tigers for features desirable for production of healthy cubs by artificial insemination is being planned.



The Molecular Characterization of Silkworm Races by DNA Finger Printing

DNA genotyping of silk worms for sericulture industry is yet another programme of its kind being taken up for the first time. CCMB is collaborating with the Central Silk Board of India in identifying and selecting the best races of *Bombyx mori*, the most economically important silk secreting worm that can be used by farmers and sericulturists for the production of high yields of quality silk. DNA from 13 different ecotypes and inbred lines of

Bombyx mori have been finger printed; the presence of bands specific to diapausing and non-diapausing strains and particular genotypes, of use for marker-assisted breeding of silkworms have been found.

Reference Seed Culture (BODSEED) for BOD Determination

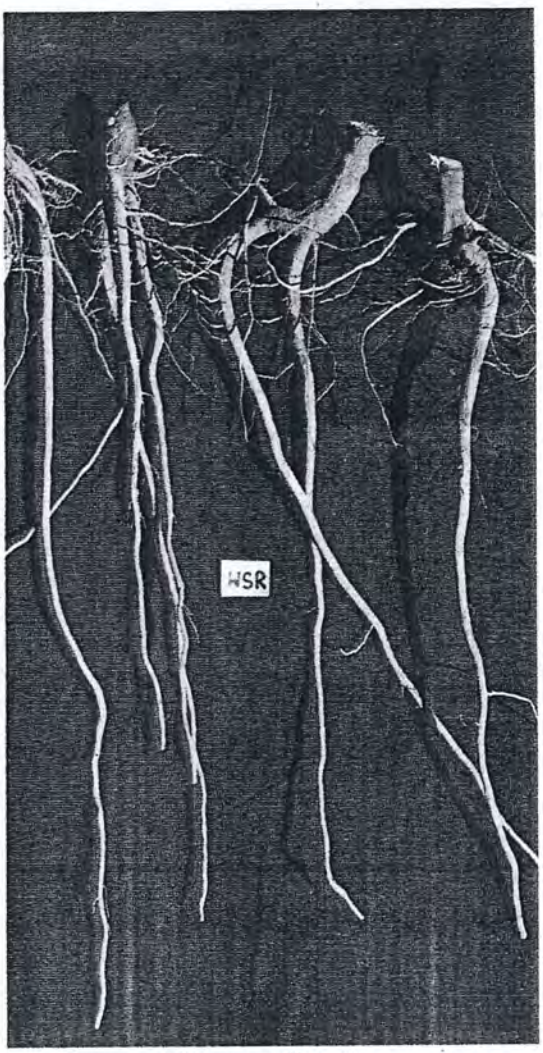
Biochemical Oxygen Demand (BOD) is the most important and common parameter to assess the quality of waste waters. In conventional BOD test, the domestic sewage is added as a seeding material (for microbial population) to decompose organic matter present in the sample. The sewage used is not of uniform nature and hence there are variations in microbial density in terms of number and species which leads to variation in the estimation of BOD. To obliviate this problem, CBT, Delhi has developed a uniform, dehydrated microbial composition (BODSEED) covering a broad selection of microbial population. The BODSEED reduces the variability of the seeding material and thereby the chances of error and also makes BOD analysis clean and convenient.

Agrotechnology of Ashwagandha

Ashwagandha (*Withania somnifera* L.) is one of the most important medicinal plants used in Ayurvedic and Unani systems of medicine. The



Ashwagandha Plant



Ashwagandha Roots

root extract is used in a number of formulations as a nervine tonic, sedative, antihepatotoxic,aphrodisiac, and for rejuvenating. Recently the plant extract has also gained prominence as an antistress, anti-inflammatory, antitumour and CNS depressant agent. A new strain-selectant developed by RRL-Jm. yields 800-1000 kg (dry)/ha of roots and is suitable for cultivation in dry and semi-arid regions. It confirms to chemotype I of *W. somnifera* and major constituent of its root is withaferin-A. The agro-technology has been transferred to three parties and the seed material of the strain is also being distributed to growers for multi-locational field testing.

Catharanthus roseus

The leaves of *Catharanthus roseus* (Periwinkle) contain two important alkaloids – vincristine and vinblastine which are used as anticancer drugs. The roots contain an alkaloid raubasine (ajamalicine) used as a hypotensive agent. CIMAP has developed agrotechnologies for cultivation of this crop and a disease resistant strain has been identified. The crop is being cultivated in about 1000 ha area mainly in Karnataka. CIMAP has also developed process technology for production of total alkaloid of periwinkle which is being commercialised.

Antifouling Agent

NIO's search for promising environment friendly substitutes for the generally toxic antifouling chemicals led to the isolation of a compound from a marine sponge which at 0.5 to 5 ppm concentration exhibited total growth/settlement inhibition of various diatoms and at 25 and 10 ppm, of mussels and barnacles larvae respectively. A process for the isolation and application of the chemical compound has been developed and an Indian patent application has been filed.

Services

International Legume Data Base (ILDIS)

NBRI is the Regional Enquiry Centre of South Asia (RICOSA) for ILDIS. In collaboration with Royal Botanical Garden, Kew, UK, NBRI is developing a computerized database of legumes of eight South Asian countries, namely India, Nepal, Bangladesh, Bhutan, Pakistan, Myanmar, Sri Lanka and Maldives. The database is being developed under the project "design and establishment of a computerised database of legumes of South Asia", which is supported Internationally by Commonwealth Science Council, UNESCO, British Council, Royal Nepal Academy of Science & Technology (RONSAT), WWF Nepal, Tribhuvan University, Nepal and nationally by CSIR/DST/DBT/INSA.



R&D and Production Capability in Biotechnology

NISTADS has undertaken a study to assess current capabilities in production related to products of biotechnology, fermentation, biochemistry etc. Features

examined for the study included skilled manpower, equipment, facilities for BT R&D and production, number of projects relevant to BT, linkages to expand capability through access, and foreign collaborations. Major findings of the study covering 33 chosen companies show that only 19 had the features satisfying the magnitude of capabilities in R&D necessary for commercialisation of BT.

Gene Bank Facility

A gene bank of medicinal and aromatic plants, jointly supported by CSIR and DBT has been set up. It has a holding of 1800 plant accessions covering about 300 medicinal and aromatic plant species. All the accessions are maintained from season to season in the field and seeds of all the fertile accessions are suitably preserved, besides 84 accessions of 27 species are being maintained in an *in vitro* gene bank.



Gene Bank at CIMAP – Mint (left) and Periwinkle (right)

Human Resource Development

Training in Industrial and Environmental Toxicology

ITRC arranged for training of scientists from Nepal, Bangladesh and Nigeria in the area of industrial and environmental toxicology as part of their All India workshop on Biodegradation of Chlorinated Pesticides organised by the institute.

Training in Commercial Cropping of Gladiolus

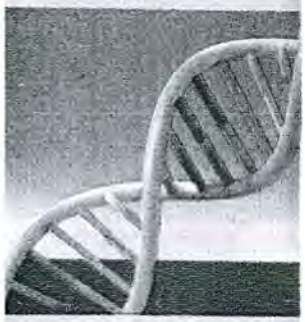
NBRI organized a five-day training programme sponsored by Small Industries Development Bank of India (SIDBI) on "Commercial Cultivation of Gladiolus" in January 1996. The programme was aimed at promoting the knowledge of identifying and evolving suitable cultivars, developing appropriate technologies for commercial cultivation under sub-tropical conditions of gladiolus, an important floral crop for cut flower trade. The trainees were exposed to various aspects of gladiolus cultivation viz., site and soil types, preparation of beds, culture method, different cultivars, irrigation, harvesting, packaging and their transport and lifting, storage of corms and techno-economics of gladiolus cultivation.

Training in Energy Plantation

NBRI organised eight training programmes sponsored by MNES, U.P. Land Development Corporation and Forest Department for growers and users of energy plantation. Training was imparted on various aspects of developing commercial nursery and maintaining forestry and agroforestry farms energy plantations, such as protected environment nurseries, water management in the field and nurseries, use of biofertilizers etc.

Recognitions & Awards

INSA Medal for Young Scientists (1995)	• Doctors Dipankar Manna & Sushmita Mukherjee, CCMB
INSA Young Scientist Award	• Dr. Sanjay Kumar, CSIR Palampur Complex
Ranbaxy Research Award for Basic Medical Sciences (1994)	• Dr. Lalji Singh, CCMB
1992, VASVIK Research Award for Biological Sciences & Technology	• Dr. Lalji Singh, CCMB
FICCI Award	• Dr. C.M. Gupta, IMT,
Third World Academy of Science (TWAS) Award for Basic Medical Sciences (1995)	• Prof. D. Balasubramanian, CCMB
Fellowship of National Academy	• Dr. H.K. Majumdar, IICB
Fellowship of Indian Academy of Sciences	• Doctors M.K. Basu & A.K. Datta, IICB
Fellowship of Indian Society of Genetics and Plant Breeding	• Doctors H.O. Misra & R.K. Lal, (CIMAP)



CHEMICALS

The chemical industry has a turnover of around Rs. 50,000 crore, with exports valued at around Rs. 6000 crore. CSIR has oriented its R&D programmes based on the global trends, market needs and the new IPR regime to assist the chemical Industry maintain its competitive edge globally. CSIR efforts have been directed towards those subsectors of the industry that are characterised by high level of innovativeness with good chemistry and where the scale-up/engineering are not the major determinants for successful commercialisation of the product or technology. R&D for the chemical sector in CSIR is carried out mainly at NCL, IICT, IIP, CECRI, CSMCRI, CFRI and RRL-Jt. with some work among others being contributed by CLRI and the RRLs at Bhubaneswar and Thiruvananthapuram.

Around 20% of staff in CSIR contributes to this sector and CSIR's record of R&D output for the sector has been quite impressive. During the year it contributed around 600 research papers, 150 patent filings (around 55% of total and 70% of international patents), 30 new technologies, 75% of the annual value of industrial production based on CSIR know-how and 80% of the exports of services and technology.

Science

Interfacial Catalysis in a Biphasic System

To avoid the problem of separation of products from catalyst in homogeneous catalysis, two phase systems have been developed in which the catalytic complex (usually a water soluble organometallic complex) remains in one phase, (generally aqueous) while the products remain in a second immiscible phase. Catalysis relies on the transfer of organic substrates into the aqueous catalyst phase, but the limited solubility of the substrates in water leads to reaction rates much lower than those for conventional homogeneous catalysis. NCL showed that catalysis at the interface of a two phase system can be enhanced by using a promoter ligand, in the organic phase, which will bind to the organometallic catalyst and thus increase its concentration close to the interface in the aqueous phase. This novel concept of promoting interfacial catalysis has been suitably demonstrated for the hydroformylation of several olefins using a Rhodium complex catalyst. This concept is also found to work in reverse. NCL has been granted a US Patent [US 5498801 dated 12/3/96] for an improved process for hydroformylation of alkenes, based on this approach. It is believed that future hydroformylation technology will be based on such two phase catalytic processes which combines the advantage of high activity/selectivity and efficient separation of catalyst and product.



The concept of promoting an interfacial catalytic reaction to enhance the rates of reaction is generic in nature, and can also be applied to other

industrially important homogeneously catalysed process. Proper choice of a biphasic system for these reactions can give enhancement in the rates of reaction. This is a very simple concept to operate on a large scale and hence may help in opening newer areas of application of homogeneous catalysis.

Living Anionic Polymerization of Methyl Methacrylate (PMMA)

Living anionic polymerization of MMA is of great significance for industrial application. However polymerisation of MMA in a living fashion at temperatures higher than 78°C and in more convenient hydrocarbon solvents is still an unsolved problem in synthetic polymer chemistry. NCL explored two strategies as possible solutions. One, use of counteraction chelating agents (e.g. TMEDA for Li^+) and the other use of complexing agents (e.g. $LiClO_4$). The former approach has led to living MMA polymerization upto. –10°C. While the latter approach has enabled polymerization of MMA at 40°C in toluene-THF (90:10) mixed solvents. The reactions have been comprehensively examined in terms of kinetics, copolymerization, and polymer molecular properties. PMMAs made by anionic polymerization method are expected to have superior mechanical/optical properties. Thus a practical and commercially feasible route to highly syndiotactic PMMA is highly desirable for industrial use.

Photocatalytic Studies of Transition Metal Complexes and Semiconductors

(i) Photocatalysis for environment protection: Photocatalytic means of destroying water bound organic pollutants is developing into an alternative water treatment technology, and is considered a new member of advanced oxidation process (AOP). Studies at CSMCRI using TiO_2 semiconducting powder which absorbs UV-light has enabled photocatalytic destruction of herbicides, haloaromatics, surfactants and dyes. Various modifications on semiconductor were affected and used in these experiments. A notable achievement has been the establishment of the applicability of Indian commercial TiO_2 powder (after certain pretreatment) to destroy organic pollutants.



Experiments for photocatalytic degradation of organic pollutants conducted both at bench level and in the field confirm the technique's potential to emerge as a viable technology for waste water treatment. Environment upgradation by photocatalysis is most suitable to India due to the abundant availability of sunshine in all seasons. CSMCRI is presently developing a "falling-firm" reactor for field test.

(ii) Photochemical supramolecular devices: Recent trends in inorganic photochemistry points to progressive displacement of interest from intra-

and intermolecular photochemical processes towards processes occurring in supramolecular systems. CSMCRI initiated work to develop a photochemical molecular device in which electronic energy originating upon light absorption can be channelised in any desired direction along the supramolecular structure by a suitable choice of molecular components and spacers. A number of mono-, di-, tri- and tetranuclear complexes for ruthenium (II) with designed polypyridyl legends have been synthesised and characterised. Redox behaviour of these complexes has been studied electrochemically. Photophysical properties of these complexes have also been studied in some cases, specially in multinuclear systems, and interesting excited state properties indicating emission quenching due to energy transfer have been observed. Photochemical studies of Mn(III) schiff bases and Co(bby) (polypeptide) complexes have been performed for better understanding of the mechanism of the photosynthetic process or the structure of vitamin B-12. With an aim for solar energy conversion, photogalvanic cells have been constructed incorporating organic dye in the stationary state and their efficiency has been tested.

(iii) Optically non-linear material: Optically non-linear (NLO) materials deal with the interaction of applied electromagnetic fields in various materials to generate new electromagnetic fields altered in frequency, phase or other physical properties. Thus NLO materials are able to manipulate photonic signal efficiently and hence find important applications in optical communication, optical computing and dynamic image processing. The search for good NLO material, developed from transition metal/organometallic compounds has currently gained momentum, because of the demonstrated, possibilities of higher NLO response, ultrafaster response time, intrinsic tailor ability of the constituent molecular structure. To meet this basic requirement for the design of an efficient NLO material, CSMCRI has synthesised a set of new mono/ binuclear transition metal complex incorporating ferrocenyl unit. Donor-acceptor property of these complexes has been established through cyclic voltammetry, square wave voltammetry and differential pulse polarography.

Solubilization of Gelatin and Formation of Organogels



A reversible sol-gel phase transition phenomenon is observed for solubilized gelatin in AOT reverse micelles. The phenomenon has been applied by IICT for immobilization of enzymes such as lipase, x-chymotrypsin, horse radish peroxidase, alcohol dehydrogenase and esterase from thermophilic bacteria at low temperatures. The immobilized enzymes have been tested for their performance in resolution of various racemic alcohols, synthesis of aspartame, resolution of naproxen, etc. The parameters are being optimized for obtaining chiral products of high optical purities.

Enzyme Catalyzed Stereospecific Reduction of Carbon-carbon Double Bonds

Enzyme enoate reductase (E.C.1.3.1.31) and enzyme alcohol dehydrogenase (E.C.1.1.1.1.) present in Baker's yeast (*Saccharomyces cerevisiae* NCIM 3305) can act simultaneously on a, β-unsaturated ketones, ketoacids and ketoesters. The reduction of prochiral carbon-carbon double bond and the keto function occurs stereospecifically yielding chiral products of high optical purity (87-99%). A novel methodology of using a rotating drum bioreactor for carrying out the biotransformations using immobilized biocatalyst for bench scale reactions has been designed, by IICT.

Synthesis of Antiviral Acyclonucleotides

A new synthesis method via. catalytic processes to get 2-Hydroxymethyl-1, 4-butanediol by hydroformylating the ketal of cyclohexanone and 1,4-butene-diol has been developed by IICT. The aldehyde is reduced to alcohol and hydrolysed to give the said triol. Hydroxymethylation of the hydroformylation product led the new synthesis of homopentaerythritol. The triol is used in the synthesis of famciclovir and penciclovir which are virucidal acyclonucleosides.

Synthesis of Azamacrolides

Azamacrolides are a new class of alkaloids with insect repellent activity attributed to their molecular skeleton. Structure of one of the five azamacrolides isolated by IICT, viz., epilachnene, constituting 90% of the secretions was confirmed by NMR spectroscopy, while those of the other azamacrolides were characterised by mass spectral and vapour phase IR studies. Scarcity of the natural product precludes a detailed study. IICT initiated a project to synthesize the azamacrolides and their major component, (+) 9-propyl-10-azacyclodecan-12-olide. Some success has already been achieved.

Photochemistry of Squaraine Dyes



Squaraine dyes have important applications in imaging science and in the sensitization of wide bank gap semiconductor materials. The symmetric D-A-D (donor-acceptor-donor) arrangement of symmetrical squaraine dyes causes an interesting effect on the formation of intramolecular charge transfer states. As a result, the photophysica properties of these dyes are highly sensitive to substituent groups and the solvent medium. RRL-Tvm. has synthesised a new class of squaraine dyes that contain an ionophoric moiety. Ionophores that are covalently linked to chromophores exhibit intermolecular charge transfer (ICT) transitions. Excitation of such molecule causes a redistribution of their charge densities, which can significantly affect the metal ion binding ability of the ionophoric unit.

Liquid Membranes for Removal of Phenols from Waste Water

A novel concept of integrating emulsion liquid membrane in a microporous hollow fiber extractor was studied by IIP for phenol removal from waste water. This new concept overcomes the normal problems encountered of leakage and swell while using conventional liquid membranes.

Electrochemical Studies of Redox Reactions

Electrochemical studies of redox reactions pertaining to petroleum industry were carried out at IIP. It was seen that cyclic voltametry of creating iron-chelates in the absence and presence of specific organic buffers gave mass transport data of the iron species. The data so generated would be useful in optimising the buffer concentration in the iron-chelate formulation for hydrosulphide ion oxidation.

Technology

Co-Based Chemicals

Development of a low pressure synthesis of cobalt carbonyl catalyst under sponsorship from an industrial unit was taken up at IICT. The catalyst sodium tetra carbonyl cobaltate was synthesized at low pressure (20 kg/ cm^2) in toluene solution with recovery of cobalt after carbonylation reaction. The catalyst is useful for carbonylation of benzylchloride, chloroethyl acetate and chloromethyl naphthalene into phenyl acetic acid, diethyl malonate and naphthalene acetic acid, respectively. It has been used in the process of preparation of phenylacetic acid.

Cyanuric Chloride

The technology for cyanuric chloride, a valuable intermediate in the manufacture of diverse chemicals, is the monopoly of only two companies the world over. A technology package covering, process knowhow and detailed design for a 720 TPA plant along with hazard and risk analysis data, has been licensed by IICT to a private sector firm.



Biosynthesis of Aspartame

Biochemical reactions offer environmentally cleaner and more cost effective processes for the production of chiral compounds. Aspartame an artificial sweetener, comprises of L-aspartic acid and methyl ester of L-phenylalanine coupled through a peptide bond. A process of continuous production of high purity L-aspartic acid using immobilised *E. coli* cells was developed by CCMB. A collaboration was forged with IICT for synthesis of L-phenyalanine. CCMB is developing the enzymatic route, using a bacterial protease, thermolysin, to carry out the coupling between

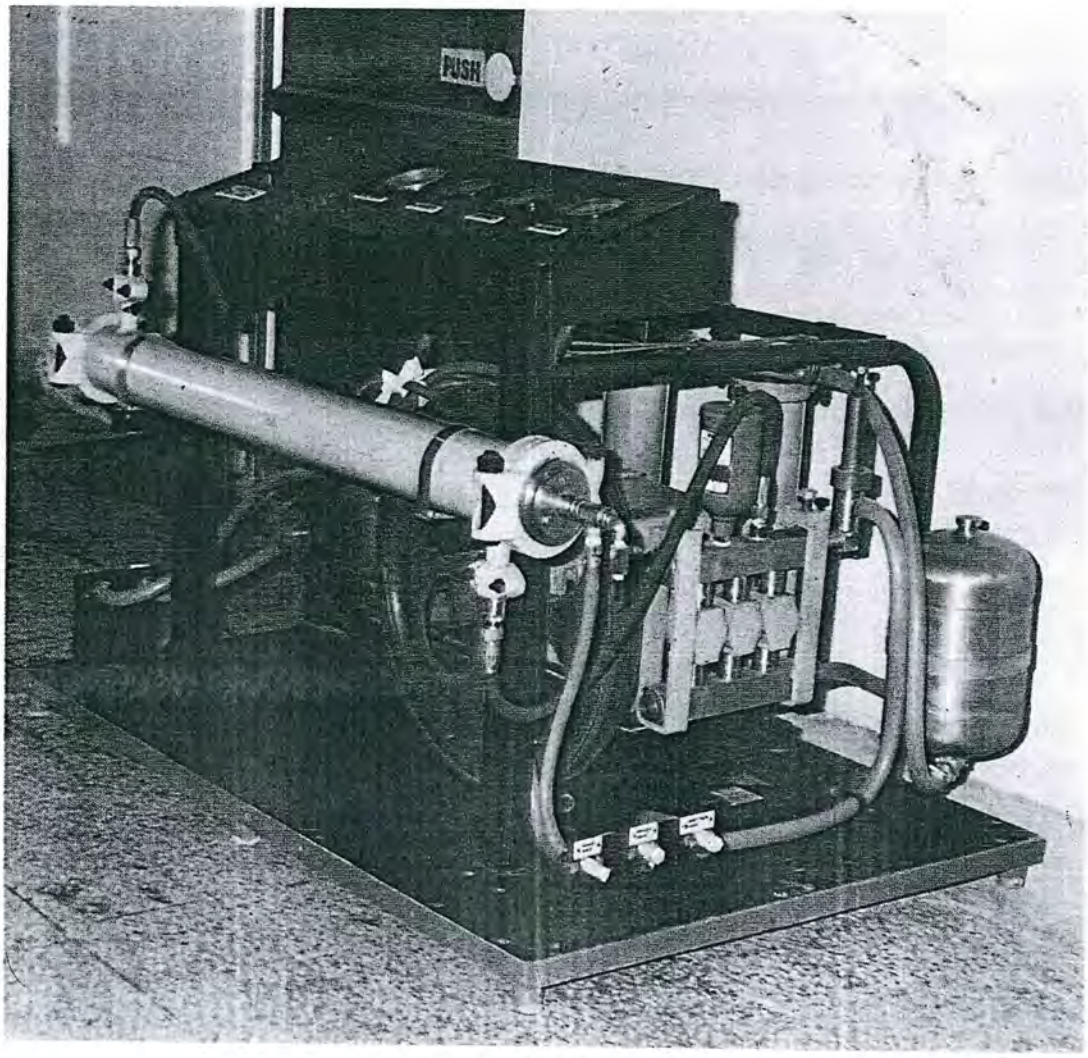
the two amino acids. The utility of alternative enzymes in place of thermolysin is being explored to make the process more cost effective.

Organoclays for Grease Making

CSMCRI in collaboration with R&D Centre of IOC has developed organo clays to produce greases with superior properties of water repelling and better friction reduction at both extremely high and low temperatures.

Thin Film Composite Membrane for Desalination and Other Applications

Thin film composite (TFC) membranes provide choice in selecting two different polymers for the layers and as a result there is direct control on the formation of the "top" layer responsible for the separation of dissolved salts from an aqueous system. CSMCRI has developed TFC membrane for desalination of seawater in single pass with 98.3 to 98.7% separation with 30 Ş 3 gfd as the flux. The substrate is a polysulfone and the thin film is of polyamide, both prepared under optimised conditions, using the casting and coating machines designed and fabricated at the institute. A prototype RO unit fabricated using the TFC was supplied to



Prototype RO Unit for CLRI



CLRI, Madras for treatment of ground water and to study the membrane performance with tannery effluent.

Explosive Composition

A cap sensitive explosive composition suitable for rock excavation, shaft shrinking, road construction, etc. has been developed by CMRI which does not use metal powder and molecular explosive ingredients. The explosive composition compares favourably in cost to metal powders.

NMP based Lube Extraction

IIP has developed an innovative, energy efficient, environment friendly process for the extraction of lube stock using NMP as a solvent. The process has been adopted by a major refinery with significant gains in productivity.

Change over from Sulfolane to NMP for Food Grade Hexane Extraction

Food Grade Hexane (FGH) is used as a solvent for extraction of vegetable oils from seeds. A state-of-the-art technology for liquid-liquid extraction of FGH with sulfolane as solvent developed by IIP has been commercialised. The Institute has now upgraded the technology to use NMP as solvent which has the advantages of savings of around Rs. 1.5 crore in initial solvent inventory, 20% saving in utilities and 6-7% increase in yield with improved product quality. IIP has developed a total engineering package for revamping of the existing sulfolane extraction plant of BPCL refinery at Mumbai to use NMP solvent.

High Temperature Antioxidants

These antioxidants find use as additives in high temperature mouldings of plastics. The hindered phenols based butylated hydroxyhydrocinamates used in plastic industry antioxidants, are monopoly of only a few multinationals. IIP developed a novel process scheme based on a new catalyst which gives higher space time yields making the process globally competitive. A plant of 1000 TPA capacity is under construction based on total technology package developed at IIP.



Improved Technology for Impregnating Pitches

Impregnating pitches are used for manufacturing graphite electrodes for steel aluminium industries. An energy efficient process for producing these pitches has been developed at IIP which leads to increased output with short cycle duration. The process involves use of a hitherto unsuitable indigenous refinery stream and eliminates import of feed stock. A plant of 4 tonnes/day is under installation.

Sulpholane Extraction for BT Production

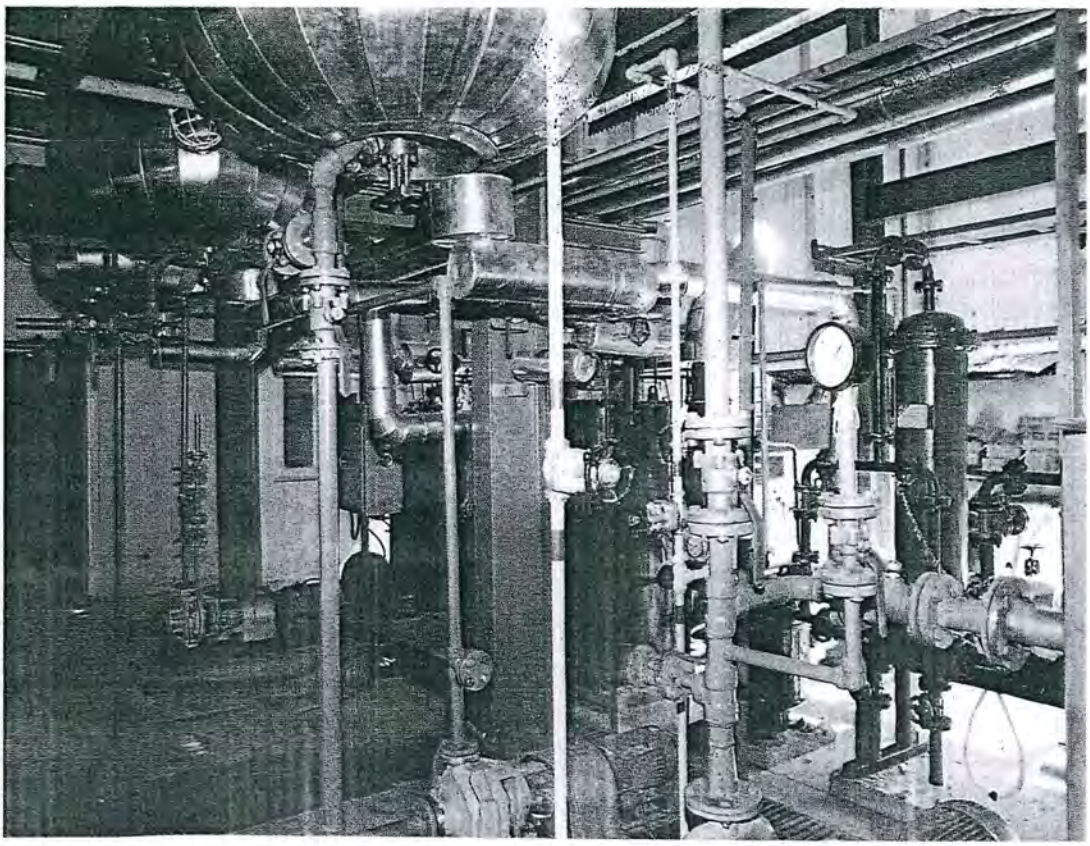
During the year the technology was transferred to NOCIL, Mumbai, against global competition, for production of 90,000 TPA of benzene and 110,000 TPA of toluene. The technology for solvent extraction of benzene and toluene developed at IIP is commercially proven and is in operation in large scale plants of two Indian refineries who were licensed the technology earlier.

Services

Multipurpose Catalyst Pilot Plant

A catalyst pilot plant facility commissioned at NCL in June 1995 is ready to take up the scale-up studies and also the semi commercial manufacture of catalysts. The pilot plant is backed up by experts in the field of synthesis and supported by in-house sophisticated characterization/ evaluation and process optimization facilities.

The multipurpose pilot plant for the preparation of zeolite and mixed oxide catalysts has facilities for washing, drying, calcination and formulation of catalysts besides analytical set up for the evaluation of raw materials and final products. The plant fully equipped with independent utilities can produce about 10 tons per annum of different types of catalysts such as zeolites, silica aluminas, mixed oxides and supported metal catalysts.



Multipurpose Catalyst Pilot Plant at NCL



The plant has been used for studying the scale up of a number of catalysts developed recently at NCL. The facility would be made available to other R&D institutes, industry and CSIR laboratories.

High Resolution Mass Spectrometer

A sophisticated analytical facility of a fully automatic High Resolution Mass Spectrometer (VG, AUTOSPEC-M) has been obtained by IICT. The high performance unit has a resolution of 60,000 and capacity to analyse ions of 3000 Da at 8 KV acceleration voltage. The LSIMS facility is available in addition to the normal EI and CI techniques. The unit is interfaced with gas chromatograph through capillary columns. High sensitivity and accuracy of the mass spectrometric techniques, make the instrument an indispensable analytical tool for characterization of organic compound of complex structures. The laboratory will be commissioning the facility for undertaking molecular structure elucidation for in-house projects and also on commercial basis for external parties.

Human Resource Development

Training in Paint Technology

A five day workshop on "Paint technology – a brush up" was organized by IICT in August, 1995 for refreshing the knowledge base of participants who were mainly from the small scale paint industry. The workshop comprised lectures by experts in the field and practical demonstrations.

Training of Personnel from Petroleum and Petrochemical industries

Under its regular schedule of arranging tailor made orientation and advanced training programmes in petroleum refining, petrochemicals and utilisation of fuels and lubricants under sponsorship by industry, IIP arranged two programmes during the year.

(a) twelve programmes of 1-3 weeks duration for middle level executives from the petroleum and petrochemical industry. A total of 233 executives from six industrial firms were trained in various aspects of petroleum refining and petrochemical industrial operations.

(b) An advance level 4-day programme on Advances in Petroleum Refining Technology and Related Aspects for senior level executives. A total of fifteen personnel at the level of General Managers and Deputy General Managers took part in the programme.



Foreign Member of Royal Academy of Engineering	• Dr. R.A. Mashelkar, CSIR
Third World Network of Scientific Organizations (TWNSO) Prize for Process Technology	• Dr. Paul Ratnasamy, NCL
Fellowship of Indian Academy of Sciences	• Doctors Sourav Pal & M.G. Kulkarni, NCL • Dr. M.K. Gurjar, IICT
Fellowship of National Academy	• Dr. H.K. Majumdar, IICB • Doctors P.K. Ranjekar & V.R. Choudhari, NCL
1993 VASVIK Research Award for Chemical Sciences & Technology	• Dr. V.R. Choudhari, NCL
FICCI Award	• Dr. Paul Ratnasamy, NCL
Goyal Award in Polymer Science and Engineering	• Dr. R.A. Mashelkar, CSIR
Hari Om Ashram Prerit S.S. Bhatnagar Award for Catalysis	• Dr. (Mrs.) K.I. Kureshi, CSMCRI
1995 Kamal Kumari National Award for Science & Technology	• Dr. T.S.R. Prasada Rao, IIP
CSIR Technology Prize for Chemical Technology	• Sarvashree R. Konda Reddy, M. Anandam, G. Laxman Reddy, K.V. Avadhanulu, M. Kaleemuddin & U. Ashutosh, IICT
CSIR Prize for Business Development & Technology Marketing	• Sarvashree R.R. Hirwani, P. Venugopal & G. Prabhakaran, NCL
CSIR Young Scientist Award for Chemical Sciences	• Dr. Manabjyot Bordoloi, RRL-Jt.
Raman Research Fellowship	• Dr. M.R. Reddy, CSMCRI



DRUGS & PHARMACEUTICALS

The Indian drug and pharmaceutical industry, synergistically supported by domestic R&D, has greatly contributed for improving the standards of health-care in the country. The success of the industry so far has been mainly due to development of innovative, appropriate and cost-effective process routes, by in-house R&D units in industry as well as those acquired from the national laboratories for manufacture of bulk drugs. The signing of GATT however has introduced new challenges to R&D that crucially affect the sector. CSIR is making concerted efforts to reassess the priorities and strategies to meet these challenges by way of generating innovative and environment friendly manufacturing processes for off-patent drugs and also introduce atleast some exclusive drug molecules.

Whilst only one CSIR laboratory, CDRI, is exclusively devoted to R&D for new drug development, significant R&D work related to development of both allopathic and herbal formulations is carried out in six other laboratories viz. CIMAP, IICT, IMT, NCL, RRL-Jt. and RRL-Jm., another six laboratories contribute R&D of relevance to this sector per se, namely, CBT, CCMB, IICB, NBRI, NIO and CSIR Palampur Complex.

Science

Development of Live Oral Recombinant Vaccine for Cholera

Cholera is the most feared among the enteric diseases. However a saving grace is that cholera is a highly immunizing disease conferring long time protection to the patient. While complete eradication of cholera is unachievable because of environmental reservoirs for *Vibrio cholerae*, it is possible to develop a safe and efficacious live oral vaccine. The recombinant vaccines developed recently have been found to be reactogenic in human volunteer studies, causing residual diarrhoea and other side effects. The reason for this reactogenicity could be the presence of other yet unknown virulence genes. In order to tackle this problem a collaborative project between IMT, IICB and National Institute of Cholera and Enteric Diseases, Calcutta was initiated to develop a recombinant live oral vaccine strain from naturally occurring non-toxinogenic and non-reactogenic clinical isolate devoid of all known toxin genes.



The vaccine strain was developed from a nontoxinogenic clinical isolate with above properties by mobilizing 'ctxB', the immunogenic component of cholera toxin under its own promotor, S-D sequence and "terminator" sequence into *V. Cholerae* chromosome at haemolysin locus using recombinant DNA technology. In RITARD model the vaccine was nonreactogenic and offered hundred percent protection against homologous challenge with toxinogenic *V. Cholerae* 01 strain of both the classical and ELT or biotypes. Attempts are being made for human volunteer trials. An international patent application to cover the strain is under process. If

successful in trial studies the vaccine is expected to be introduced in the market in about three years' time.

Spontaneous Tumour Regression

CCMB has been studying the mechanisms responsible for the spontaneous regression of a macrophage tumour termed AK5 generated in syngeneic rats. Natural killer cells activated by the antitumour antibody induce the tumour cells to undergo programmed cell death or apoptosis. Apoptosis of tumour cells was inhibited when they were transfected with the Nedd 2 gene in antisense orientation implying that Nedd 2 expression is required for tumour regression. The identification of a gene product that can induce apoptosis, specifically in cancer cells, is of great value in cancer immunotherapy.

BS RNAse, an Anti Tumour Agent

Bovine seminal RNAse (BS RNAse) has aroused interest because of its associated anti tumour activity. Studies of CCMB show that the relative concentration of RNAse and substrate may modulate the RNAse activity that is responsible for the anti tumour action.BS RNAse can form two kinds of dimers: the M = M and M x M forms, each of which is held together by disulphide bridges and hydrophobic interactions. Under reducing conditions the M = M form gets converted to the monomer but the M x M form becomes a noncovalent dimer (NCD). The effects of the protein RNAsin (RNAse inhibitor) and the substrate RNA on the equilibria between the XM x M, M = M, NCD and monomeric forms of BS RNAse were studied. The inhibitor stabilises the monomeric form (which is inhibitor sensitive) whereas the substrate stabilizes the NCD (which is inhibitor insensitive).

Leads from Plants Growing on Cattle Dung Heaps

Cattle dung is used as a cheap source of manure in India, Ironically the dung does not permit germination of plant seeds and growth of seedlings for long on these heaps, due to impeding factors such as hyperthermia from microbial espiration, growth inhibitors secreted by microorganisms and high salinity. However certain plant species have been observed to be growing on fresh decomposing dung heaps. A study was conducted at CIMAP to identify such plants (termed as coprophilous plants) and to investigate the possible relationship between this property and known biological activities of the plants. Plants belonging to 82 species under 32 difierent families were found growing on the dung heaps with the relative proportion of herbs, trees, climbers and shrubs as 17 : 5 : 2 : 1 on an average of 7 plants per dung heap. It was seen that 72% of the plant species possessed one or more biological activities: 30% antiviral, 45% antibacterial, 30% insecticidal, 25% anticancer, 20% antiprotozoal, 48% antifungal and 23% allelopathic activities. While *Azadirachta indica* and *Echinochloa crusgalli* were found present in more than 50% of the sites.



The experiment suggests that plants which are thermotolerant, salt-tolerant, or tolerant to growth inhibitors produced by microorganisms or are able to retard the growth of antimicrobial substances can survive on dung heaps. The screening of such plants, that are well represented on fresh/decomposing dung, will provide useful information to identify the plants for pharmaceutically and agriculturally useful chemicals and for genes that provide thermal and saline tolerance to plants.

Diagnosis of Tuberculosis

A 1.3 kb cloned DNA fragment of *M. tuberculosis* containing repetitive sequences has been identified by CDRI which hybridizes to clinical isolates of *M. tuberculosis* DNA with 100% specificity. Analysis of DNA fragment and restriction analysis establishes it as a new fragment not reported earlier. A patent has been filed for the development.

Technology

Chandonium Iodide

Chandonium iodide developed at CDRI is a new non-depolarising neuromuscular blocking agent used to interrupt transmission of nerve impulse at the skeletal neuromuscular junction. The major advantages of this new drug over the commonly used muscle relaxants, are its quicker onset of action and better cardiovascular stability and non-release of histamine. Chandonium iodide is stable at room temperature and has longer shelf life. This makes the drug more useful in periphery hospitals where the refrigeration facilities are not available, particularly in the developing world. Technology has been transferred to industry.

Kala-azar (Leishmaniasis) Diagnostic Kit

A test kit for the early diagnosis of kala-azar has been developed at CDRI. The test is based on agglutination of homologous antigen and antibody and detects antibodies in the sera of kala-azar patients before the clinical manifestation of the disease. The test has been validated in the sera of over 3,000 human subjects in the endemic and non-endemic areas. The test, simple, economical and field oriented, is highly sensitive and specific (98%) and can be performed on very small quantities of blood (0.02 ml). This is the first global introduction of a simple and reliable test developed for the early diagnosis of kala-azar. The kit has been launched under the trade name 'Leishmatest'.



Acyclovir

CDRI has developed a novel process technology for manufacture of acyclovir a synthetic analogue of guanine used for the treatment and prophylaxis of a number of viral infections, namely, – Cytomegalo virus, Epstein-Barr virus, Herpes simplex virus, Herpes virus 6, Pseudo-rabies virus and Varicella-zoster virus. In addition, it has now found a major use in the treatment of



Leishmaniasis Kit

AIDS virus, aplastic anaemia and hepatitis. The tentative world market of this drug is over US dollar one billion (about over Rs. 3,000 crore). Technology has been transferred to industry.

Leuprolide

Leuprolide acetate is an analogue of gonadotrophin release hormone (LH-RH agonist), used for the suppression of testosterone in the treatment of malignant neoplasms of the prostate. The current world market of the drug is about US dollars eighty million (Rs. 250 crore). Technology for the drug developed at CDRI has been licensed to industry.

Mefloquine

Mefloquine hydrochloride is the preferred drug for use in chloroquin resistant and cerebral malaria. Mefloquine is not easily available because there is only one manufacturer of the drug in the world. The known process routes for making Mefloquine are fraught with many difficulties, the most serious being the use of alkyl lithium reagent. IICT has developed an innovative method for making Mefloquine which dispenses with the use of alkyl lithium reagent. The process was optimized on bench scale and licensed to three parties, of which one has already established commercial production.



Ondansetron

Ondansetron is used as a therapeutic agent to mitigate emesis due to chemotherapy treatment for cancer. The IICT developed process, now in commercial production, uses 1,3-cyclohexandione as a key intermediate and other raw materials available indigenously. The process replaces the more

expensive chromatographic separation techniques for purification by crystallization. As a consequence the price of the domestically produced product is several times lower than the prevailing international price.

Citirizine

Citirizine is the preferred non-sedative, anti-histamine. A modified process for production of citirizine developed by IICT has been transferred to industry for commercialisation.

Stavudine

Stavudine (duT) is an anti-AIDS drug recently approved by FDA, USA, for the treatment of AIDS in combination with AZT. The knowhow for production of Stavudine developed at IICT under sponsorship from industry has been licensed to the sponsor for commercialisation.

Memory Drug from Brahmi Extract

The effect of Indian herb brahmi (*Bacopa-monnieri*) for augmentation of memory and sharpening of intellect is well established in the ancient traditional system of medicine. CDRI has developed a standardised extract of Brahmi on the basis of the active chemical constituents – Bacosides. The Bacosides significantly enhance brain protein synthesis known to be linked to memory formation, thus linking their role in improvement of memory. The standardised preparation has been tested and found to facilitate learning in animal models and its safety has been established through regulatory pharmacology and toxicology studies. The technology has been licensed to one party which has already established commercial production.

New Antileishmanial Compound of Indigenous Plant Origin

A new antileishmanial compound was isolated by IICB from the crude extract of indigenous *Swertia chirata*. The active component is an irridiod glycoside. The pure compound showed highly leishmanicidal properties in minimum dose levels with the niosomal form being more potent than the liposomal form. Toxicity studies in the form of LD50, histological staining of tissue, blood pathology and specific enzyme level related to normal liver function showed that the compound is apparently non-toxic to the host. Detailed toxicological studies are underway in CDRI/ITRC, Lucknow. A patent application has been filed for the development.



Isolation of Natural Analogues of Taxol from Taxus wallichiana (syn. Taxus baccata)

Himalayan yew (*T. baccata*) trees containing as high as 0.5 taxol xylosides have been identified by CIMAP. Around 20 taxanes and rearranged taxanes have been isolated and characterized, of which three are new. Conditions have been standardized for initiation of callus cultures from young stem and needle explants; two taxanes have been detected in the callus cultures.

A simple and cost effective method for the conversion of the taxol xyloside into taxol has been developed by CIMAP. Six patents have been filed and technology transferred to industry.

Services

Testing and Analysis

CDRI provides supporting technical services to research institutions, hospitals and industry in toxicity testing, biological screening, physiochemical analysis. During the year the laboratory received and carried out test and analysis for over 20,000 samples.

Supply of Laboratory Animals

CDRI having the National Laboratory Animal Centre continued to maintain and supply animals of different species as well as animal organs to research laboratories all over the country.

NICDAP

The National Information Centre for Drugs & Pharmaceuticals (NICDAP) provides information support in terms of bibliographic and patent searches, supply copies of research papers etc. Over the years its monthly publication "Industry Highlights & R&D Highlights" have become pace setters in the area. The reach of NICDAP has been substantially increased by CDRI becoming a Distributed Information Sub Centre of the Biotechnology Information System and as a WHO Collaborating centre on Drug Information and with connectivity to INTERNET.

Human Resource Development

Training Programmes

CDRI provided advanced long term training for candidates from industry in 17 areas of its R&D expertise. It also offered short term training in Quality control of drugs and pharmaceuticals, Fermentation technology/microbial genetics, Methodologies, structural elucidation and quality control of natural products, Chemotherapy of malaria, Immunology of leishmania etc.



Recognitions & Awards

Fellowship of National Academy of Sciences	• Doctors R.K. Chatterjee, M.M. Singh & S.K. Basu, CDRI
Fellowship of Indian National Science Academy	• Dr. B.S. Setty, CDRI
INSA Young Scientist Medal for Medical Sciences	• Dr. (Mrs) Pratima Srivastava, CDRI

EARTH RESOURCES

Natural resources constitute the foundation of economic and social development of a country. In the Indian context, a wide gap exists between demand and quality for these resources viz., oil, coal, minerals and metals and their domestic reserves, calling for the stepping up of efforts for the exploration and harnessing of domestic services. Specifically, fuel (coal & crude oil) is the single largest item of imports after capital goods, accounting for over 20% of imports valued at around $ 6 to 7 billion annually; exploration and judicious utilisation of ground water has become essential for our very survival; so also containing the damages due to earthquakes and other natural calamities.

Two CSIR laboratories, NGRI and NIO are exclusively devoted to R&D for earth and oceanic resources; while CBRI, CRRI, SERC-M, NEERI and RRL-Jt. have expertise and facilities to contribute on specific aspects of activities of relevance to the sector.

Science

Seismic Hazard Assessment and Earthquake Prediction

Studies of NGRI on earthquake predictions have yielded valuable results that help in redefining the isoseismic prospecting zones and demarcating earthquake prone zones. An earthquake catalogue was compiled and the characteristic features of earthquake occurrence models were analysed. Also first order general purpose seismic hazard maps of the GSHAP test area 8 covering Eastern Himalayas, North Eastern region of India, Myanamar and adjoining regions of China and South East Asia were prepared. The "SEISMOLAP" program for earthquake prediction was test applied for earthquakes of the Koyna region. The NGRI published the Morphostructural Zoning Map of India along with explanatory literature.

Gas Hydrate Exploration

Gas hydrates, the ice-like structures formed when gas (methane) molecules are caged by water molecules, seem to hold the key for future energy resources. Gas hydrates are basically found in two distinct geographic environments, viz. permafrost regions and also in deep marine sediments along the continental margins. With a view to explore the possibility of the Indian continental margins, with their abundant sedimentation as a potential source of gas, the Gas Authority of India Ltd. sponsored a project at the NGRI. The project envisaged evaluation of all available geophysical and geological data along the continental margins, so as to recommend suitable sites/areas for possible future investigations.



Mesozoic Sediments

Data collection for the ONGC sponsored project at NGRI on seismic refraction, magnetotelluric gravity and deep resistivity was completed. Studies

were carried out in the Saurashtra peninsula to delineate possible oil bearing mesozoic sediments under the Deccan volcanic cover. Integration of various models is being done to evolve a unified model for the entire peninsula.

Evolution of the Eastern Ghats Granulite Belt

NGRI carried out field, petrological and geochemical studies on the megacrystic charnockites and granites at Paderu area of Visakhapatnam with a view to understanding their origin and evolutionary history. These megacrystic rocks form a NE-SW trending body intruding the khondalites and sapphirine bearing granulites which occur as enclaves. These granites occur along the shear planes of the megacrystic charnockites, the contact between the two being usually sharp. The overall chemical variations indicate fractionated S-type character and syn-to late and post-collision tectonic setting for the granites. The charnockites appear to have formed from a deep seated magma, generated by partial melting of deep crustal metasedimentary rocks, while the granites are formed by retrogression of the charnockites.

Seismic Tomography of the Indian Shield

Using the existing data NGRI attempted to present a 3-D velocity map of the Indian Plate. As a first step, the surface wave group velocity distribution over the Indian region at different time periods was computed ranging from 15 to 60s corresponding to depth levels of 20-90 km. The study showed certain characteristic differences among various geotectonic regions, viz.: (a) High velocity crust and upper mantle beneath the Deccan Traps; (b) Anomalous low velocity deep crustal signature from the Godavari and Eastern Ghats; and (c) A regional low velocity beneath the Indo-Gangetic plain.

Carlsberg Ridge System

As part of its collaborative work with GSI, NGRI undertook detailed magnetic and bathymetric surveys over the SE part of the Carlsberg ridge delineated NW-SE trending fracture zones offsetting the anomalies by 10 and 21 km respectively have been identified by profile to profile correlation of magnetic anomalies. The Ridge is characterized by deep axial valley with rough topography on the flanks which is indicative of slow spreading ridge.



Tectonic Model for the Evolution of Oceanic Crust in the Northeastern Indian Ocean

The attention of international scientists was drawn on the greater offset in key magnetic lineations on opposite sides of the 86°E Fractures Zone against the corresponding ridge segments of the Southeast Indian Ridge in the eastern Indian Ocean. A tectonic model was suggested for the first time by NIO to explain the evolution of extra oceanic crust spanning 11° in latitude on the Indian plate between the 86°E Fractures Zone and the Ninety east Ridge with a series of southward ridge jumps at different stages. The first

stage of spreading ended shortly after the formation of anomaly 30 (about 69 M) when a southward ridge jump took place. The second stage of spreading continued until anomaly 27 (about 64 M), when another southward ridge jump occurred. The third stage spreading then continued until the onset of a second major plate reorganization. These ridge jumps captured the portions of oceanic crust that initially belonged to the Antarctica plate, but was later transferred to the Indian plate. The captured portions together with offset along 86°E Fractures Zone between the India-Antarctica Ridge and the Wharton Ridge resulted in an extra oceanic crust spanning 11° in latitude on the Indian plate.

Hydrothermal Deposits in the Andaman Basin

NIO initiated studies for the search of hydrothermal deposits along the backarc basins with main thrust on the Andaman basin. Results revealed the structure of the Andaman backarc ridge to be complex mosphotectonic. Analysis of samples collected exhibited a possibility of hydrothermal activity along the Andaman backarc ridge system which was shown to have one active and one passive ridge segment as per geophysical studies conducted.



Rock Sample from Andaman Sea with Hydrothermal Vents

Modelling of Tropical Atmosphere

The convective forcings generated in the tropics play decisive roles in the prediction of weather and climatic systems. The use of models of these convective forcings for large scale weather predictions have not been very effective. C-MMACS undertook studies on a range of models of varying complexity. Results obtained provide a better understanding of the tropical dynamics and are potentially useful for developing models for the tropical weather predictions.



Neural Network for Long-range Forecast of Rainfall Patterns

Accurate long range forecast of rainfall patterns are extremely significant for calamity management, policy planning, etc. considering the limitations of conventional dynamic and statistical modelling as well as the conventional

neural networks in generating forecasts of All India Mean Summer Monsoon Rainfall (ISMR),C-MMACS developed a generalised structure termed cognitive networks. Evaluation of these networks through a number of hindcasts enabled generate annual forecasts of ISMR with average error less than one third the observed deviation. The evaluated cognitive networks have been used to generate advance experimental forecasts of ISMR for the years 1996 and 1997.

Technology

Saline-fresh Water Interface Dynamics : Krishna Delta

Based on hydrological and hydrochemical results obtained at 150 sites covering North and South Krishna delta, the water quality maps were finalised on 1:250,000 scale, and integrated with the Hydromorphological set up of the delta. For strandlines (paleoshore lines) have been identified which are areally separated by fluvial delta systems with fresh water aquifers. The areal extensions of each of the fluvial aquifers are different, with different interface depth levels and aquifer configurations. The interface depths separating fresh and saline aquifer boundaries are maximum at the upstream regions (40-50 m) and tapers down to be shockline areas (5-10 m). This would be useful to augment groundwater exploration in coastal areas where the intercalation of saline water is significant.

Services

Establishment of IGS permanent GPS Tracking Station

Under the CSIR-KFA collaboration project on Space Geodesy, a Turbo Rogue GPS SNR-8000 receiver, and BERNESE software were gifted to NGRI to establish the International GPS service for geodynamics (IGS) permanent tracking station. The IGS NGRI station is equipped with a Turbo Rogue GPS SNR-8000, 8 channel dual frequency, geodetic receiver which tracks upto 8 satellites simultaneously measuring the group delays (pseudo range) and phase delay from L1 C/A, L1-P, L2-P signals. The receiver is set to track in a fixed mode and acquire data at 30 seconds interval. The station was installed in June 1995 at NGRI in collaboration with the Geodetic Institute, University of Bonn, Germany.



Integrated Data Acquisition System (IDAS) for Sagar Sampada

A LAN based Integrated Data Acquisition System (IDAS) for scientific data collection at sea was developed by NIO for the fisheries research vessel FORV *Sagar Sampada*. The department of ocean development funded the equipping of IDAS on the ship. The system enables network-wide data to be acquired and processed in real time from any node. The data acquired is stored on a centralised Novel Netware based file server with 1.2 GB storage capacity. The IDAS computers are interfaced to GPS receiver, ship's

log and gyro, echosounders, echo integrator, CTD system, acoustic doppler current profiler, shipborne wave recorder, sea surface temperature unit and to a shipborne meteorological system.

Gravity Stations – setting up

NGRI under a ONGC sponsored programme has set up 5500 high resolution gravity stations. It has already started processing of data from over 3000 stations.

Geographic Information System (GIS) for Resource Planning and Utilisation

Expertise for application of GIS in watershed management and wasteland development planning in particular and regional planning in general has been developed at NISTADS. The expertise was utilised to prepare for the Ministry of Environment and Forests:

(a) Eco-development plan of Aravali degraded forests in parts of Haryana and Rajasthan;

(b) Environmental Pollution Information System for Central and State Pollution Control Boards as a decision support system for planning, execution and monitoring of pollution control programme;

(c) Preparation of Zoning Atlas for siting of industries in Panchmahal (Madhya Pradesh), Singhbhum (Bihar) and Ghaziabad (UP).

Human Resource Development

Training Courses

NGRI organised four week training courses for :

(a) Digital seismic instrumentation and analysis of data at the instance of DST for the staff from IMD, GSI, Wadia Institute of Himalayan Geology, Universities of Delhi, Manipur & Varanasi and CSIR laboratories;

(b) Groundwater exploration and Management Techniques.

Recognitions & Awards

Fellowship of Indian National Science Academy	• Dr. R. Srinivasan, NGRI
CSIR Young Scientist Award	• Doctors (Mrs.) C. Manikyamba & Kirti Srivastava, NGRI
National Material Award	• Dr. D.D. Singh
National Hydrological Award	• Dr. S.M. Rao



ELECTRONICS & INSTRUMENTATION

CSIR's R&D for the electronics sector has been for: (a) strategic areas where technology/product may be denied to India such as technology development for microwave tubes; (b) automation/modernisation of locale specific agro-based industries; (c) cost effective medical, agriculture and industrial instruments; and (d) two national missions on microelectronics & photonics.

CSIR's input to the sector have been mainly through CEERI and CSIO, with contributions from CGCRI, CECRI, NCL, NPL for electronics materials; CEERI, NAL, NPL for special components/devices; and CSIO, CEERI, CMERI, NAL, NGRI, NIO for instrumentation and systems.

Science

Characterisation of Structure of Single Crystals of Important Materials in Electronics

High purity gallium arsenide crystals have been characterized by NPL for their purity and perfection using high resolution x-ray diffraction techniques. These crystals are utilized for micro-wave communication and other defence applications.

Indigenization of Manufacture of B/W TV Picture Tubes

A study on indigenisation of technological change in the manufacture of Black and White TV picture tube at the firm level was undertaken by NISTADS. Two firms were selected; a firm in the public sector and a firm managed by an NRI entrepreneur in the private sector. The study shows that the public sector firm has been very effective in building up Indigenous Technological Capability (ITC) i.e. 'Technoware' and 'Humanware', and the subsequent diffusion of technology and expert manpower. However, because of weak 'Orgoware', efficiency was low and thus the firms could not compete in the market place. In contrast, the private sector firm managed by an NRI entrepreneur could perform better in the market place because of strong management of Orgoware. The study confirms that 'Learning by Doing' process at the shop floor helps to a great extent in the absorption and adaptation of imported technologies.



Technology

Word Recognition System

CEERI developed an Isolated Word Recognition System by integrating an MC 68000 microcomputer board with an audio spectrum analyser board. The system has been tested in real-time for 10 words at an accuracy of 100%. CEERI incorporated the system in a voice controlled motorised wheel chair for demonstration to the Spastic Society of India, Mumbai.



Spectral Comparison of Natural and Synthetic Speech

Piezoelectric Accelerometers

Piezoelectric accelerometers with 10 mv/g sensitivity have been developed by NPL for industrial applications and have been supplied to CRRI. This is an important import substitution item.

Optical Integrated Circuits (OIC) Devices

Under a programme supported by National Photonics Council, DoE, Government of India, development of Optical Integrated Circuits (OIC) Devices was undertaken at CSIO to establish a technology base for fabrication and analysis of various OIC components. Processing techniques for LiNb3 based passive components was established. A number of planer and channel single and multimode waveguides were fabricated by titanium indiffusion on Z-cut LiNbO3 wafers. The waveguides developed were tested and evaluated for their performance which was as per the prescribed specification.



Silicon Varactor Diodes

CEERI has developed and batch produced silicon varactor diodes eminently suited as tuning devices in TV receivers. The diodes were packaged and tested at BEL and found to meet the requisite specifications. The technology is available for licensing.

Hybrid PIN/FET Optical Receiver

The design uses InGaAs/InP photodetector and GaAs MESFET and thin film hybrid approach. Technology licensing is being negotiated by CEERI.

Infusion Pump & Controller

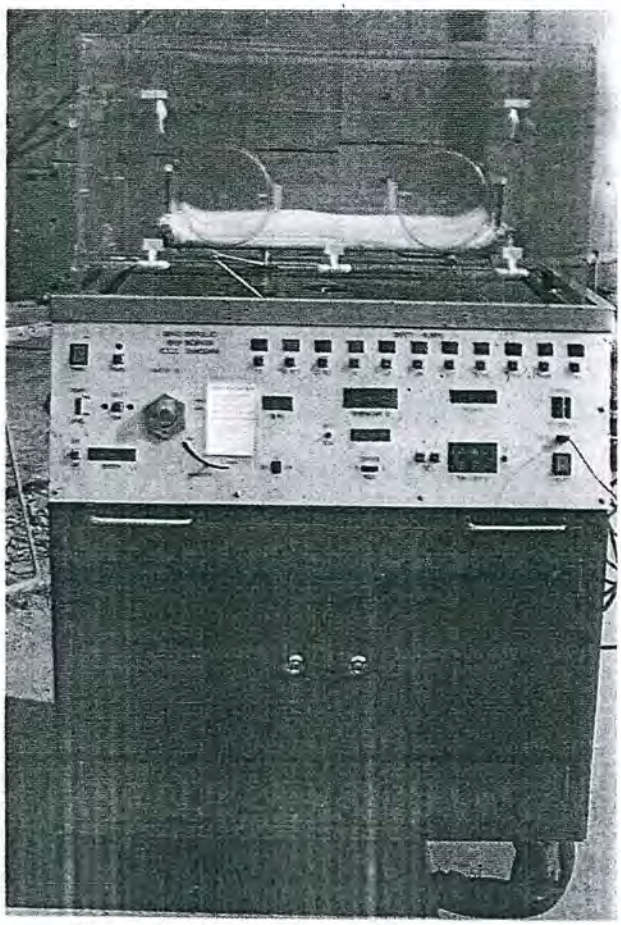
A microprocessor based drug infusion pump and controller has been developed at CSIO in technical collaboration of PGI, Chandigarh. The instrument regulates the flow of fluid through gravity feed in intravenous therapy system and maintains a precisely selected delivery rate from 1 drop/min to 99 drops/min. The instrument has LCD display of diverse parameters and in built audio and visual alarms for patient safety. Licensing of knowhow is at the stage of negotiations.

NICAM Receiver for Digital Stereo Sound in TVs

CEERI has developed a NICAM receiver that can be interfaced with existing TV receivers as an add-on-card or as a stand-alone unit. It can provide one high quality digital stereo sound channel and one FM mono. The estimated cost of the add-on-card for existing TVs is less than Rs. 2000.

Servo Controlled Baby Care Incubator

A servo controlled baby care incubator, was developed by CSIO in collaboration with PGI, Chandigarh. The device provides appropriate controlled environment to premature or sick new born babies. The temperature is maintained with an accuracy of +0.3°C with a resolution of 0.1°C. The Incubator has special safety and alarm provisions additionally to the usual alarms and safety circuits.



Servo Controlled Baby Care Incubator



S&T services for upgradation and modernisation of industry rendered by CEERI:

On-line Process Control Instrumentation

CEERI has set up complete instrumentation and automation system for a paper mill in Dharuhera (Haryana). The system ensures that products match the colour of samples.

CEERI also helped a leather finishing chemical unit in Hyderabad in the installation, commissioning and calibration of a process control system. Field trials carried out have evaluated the performance of the system to be as per the specifications.

Human Resource Development

Training programmes on Operation, Maintenance and Repair of Biomedical Equipment for Third World Countries

CSIO conducted three management development programmes on Operation, Maintenance and Repair of Biomedical Equipment for participants of the third world countries – Ethiopia, Ghana, Jamaica, Kazhakistan, Oman, Palau, Philippines, Sudan, Uzbekistan, Vietnam and Zambia.

Training Programmes on Maintenance of Scientific Instruments for SAARC Countries

A one-week specialised training programme on Repair & Maintenance of Scientific Instruments for participants from the SAARC countries of Bangladesh, Nepal and Sri Lanka was organised by CSIO under sponsorship of Ministry of External Affairs, Govt. of India through Department of Science & Technology, New Delhi.

Training in Design of ICs

The accumulated expertise of CEERI in the area of semiconductor devices was utilised by user industry for manpower development. CEERI conducted a series of lecture courses/training programmes on: (a) VLSI Design and related topics; and (b) VHDL for Design and Modelling of VLSI circuits.



Recognitions & Awards

1995 CSIR Young Scientist Award for Physical Sciences	• Dr. P.K. Khanna, CEERI • Dr. Rina Sharma, NPL
Hari Ranji Toshniwal Gold Medal	• Dr. P. Kapur, CEERI

ENERGY

India's per capita energy consumption is amongst the lowest in the world. Coal provides 60% and oil 26% of the primary energy needs in India. As against the proven reserves of nearly 70 billion tonnes of coal the annual coal production is of only 380 million tonnes. Thus there is tremendous scope for increasing mining and usage of coal through appropriate S&T inputs.

CSIR's efforts in the energy sector have thus been to assist: **the coal mining industry** to enhance production by adopting eco-friendly environmental management and reclamation techniques, provide more up-to-date testing & evaluation services and technologies for beneficiation and utilisation; and **the petroleum industry** in its endeavour to enhance capacity and to be globally competitive.

Science

Processing of Heavy Crude Residues

Studies at CFRI have established that processing of heavy residue catalytically under supercritical condition leads to better conversion compared to vis-breaking normally followed. The salient features of the process are (a) 60-65% of residue is converted principally to TCO and VGO fraction, (b) the process does not use hydrogen or any hydrogen donor, (c) the hydrogen gain in the overall product is 0.2-0.4 percent more than the starting feed, (d) desulphurisation to the extent of 30 percent in the overall product and (e) there is no coke formation.

Optimisation of Combustion Chamber Geometry of a Tractor Engine

Combustion chamber geometry of the tractor diesel engine was designed by IIP with mathematical simulation of air-fuel mixing and combustion. A engine prototype was evaluated to meet emission norms. This work demonstrates the significance of using mathematical model to design combustion chamber geometry at the design stage.



Chemicals and Liquid Fuels from Coal and Other Sources

CFRI investigated the production of liquid fuels and chemicals from coal and other sources as part of the Integrated Long Term Programme (ILTP) with the Institute of Organic Chemistry, Moscow (Russia) through F-T synthesis. Life study conducted for fresh CS-14 iron based catalyst gave 64.4% middle distillates and 47.6% diesel oil for a run period of 120 hours. The study was successfully carried out for further 250 hours. The activity was found to be satisfactory.

Also a potent catalyst has been developed for the conversion of biogas (a mixture of CO_2 and CH_4 in the ratio 1:1 to a mixture of CO_2 and H_2S – an important feedstock for chemical industries. 90% conversion has been achieved.

Technology

Mining of Thick Coal Seam Standing on Pillars

Technology for recovery of coal from 6 to 10 m thick seam pillars under shallow to deep cover has been developed by CMRI. This development facilitates extracting of coal from high seams which has been a global problem of mining engineers. India has nearly 56% of its coal reserves, locked up in pillars. The development of this technique has thus opened new vistas for exploitation of the locked up coal. The technique is being implemented in the select 3 mines of different subsidiaries of Coal India after the successful trial at NCPH mine of SECL. An allied development was to utilize the discarded coal haulage rope in the form of cable bolt. The roof support technology ensures safety to the workers and the workings enhancing the level of recovery of coal by 25 per cent.

The novel feature of the cable bolt, is its strength independent of the height of working and capable of offering anchorage upto 12 tons, more than that required for the support of the workings in depillaring panels.

Wedge Cut Blasting to Improve Productivity of Coal Mines Drivages

A novel and cost-effective wedge cut blast pattern has been developed at CMRI which improves the pull per round of drivages in coal production and thus enhances the productivity and machine utilization time. This new pattern of blasting can also be used for the underground development of drivages in mechanised coal mines and has also been proved to be effective for the improvement of drivage rate through multiple formation in tunnels for hydro electric projects.



Air Deck Blasting to Improve Productivity in Open Pit Mines

Feasibility of introduction of air deck blasting technique developed at CMRI in opencast mines has been studied. It is found that this technique of blasting is effective in opencast mines and leads to higher production through proper fragmentation, increased machine utilization time and reduction in blasting cost.

Fire Protective Coating to Prevent Heating in Coal Mines

A water based bitumen emulsion developed at CMRI is useful in prevention of spontaneous heating in coal mines and to prevent air permeation in coal dumps storage. The emulsion allows a uniformly thin coating of the order of 0.50 mm to be applied. It is cheap, durable, easy to spray and water proof.

Development of Material of Construction for Pottery Chulha

The R&D work for the development of a suitable and cheap material for construction of pottery chulha was taken up by CFRI. The raw material chosen was an industrial waste product. The results obtained so far are encouraging and efforts are in progress to find out a better binding agent for making cold-set refractory chulha/combustion chamber.

Studies on Thermal Efficiency of the Chulha

The experimental determination of temperature profile (axial and radial) of improved chulha (Angarmitra) was taken up at CFRI to find out the mechanism of combustion in the fuel bed. It has been observed that the provision of secondary air gives a thermal efficiency of 40% as compared to 30% efficiency in the absence of secondary air. Temperature profile and carbon loss studies corroborate this finding. In all, ten runs were conducted. Experiments progress to replicate results.

- Improved Chulha for Efficient Combustion of Coals
- Propagation of Angarmitra and Angarbandhu Chulha.
- Efforts made to popularise the design included distribution of samples, training and orientation course.
- Studies with Community Chulha

Modifications made during the period have effectively increased the thermal efficiency of first phase Community Chulha from 28% to 32%. Further work is in progress.



Production of Bulk Quantity Coke Briquettes

NML developed an eco-friendly process for production of briquettes from waste coke fines. It uses processed tar as binder and is highly mass and energy efficient. Trial production of briquettes using coke fines from CIL Dankuni coal complex were undertaken in a continuous briquetting machine. The product was tested for the physical and thermal properties suitable for cupola operations and found to be most advantageous.

Coal Quality Assessment

Borehole core of 20,082 metres was processed and 37,019 samples were studied by CFRI in support of the exploration carried out by GSI, CMPDI and others in 34 coal and lignite fields. The studies were carried out by CFRI and its Units at Raniganj, Ranchi, Bilaspur, Nagpur and Jorhat. In addition, 10,994 samples were analysed for Coal Controller and other customers.

In Sponpur-Bazari area, low ash power coals with 15-20% ash were proved (Raniganj Unit). In Jaisalmer area, Rajasthan, a lignite horizon recorded within 106 m with relatively low ash 12 to 15% (Nagpur Unit). In Main basin, Singrauli Coalfield, comparatively Cleaner horizon with 26% ash encountered below 50 m strata (Bilaspur Unit). Badam block, North Karanpura borehole washability studies have shown that in seam top coal yields of 50-60% at 17% ash level with G-G4 & SI : 3-6 (Ranchi Unit).

Batteries Life Cycle Testing System

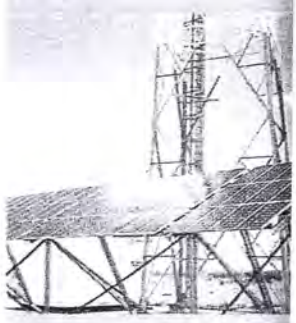
A fully automatic computer controlled battery life cycle testing system consisting of five channels for testing 12V batteries up to 250A has been installed at CECRI.

This system meets the ever-increasing stringent demands for comprehensive easy-to-use software package. Several limit conditions (e.g. time, battery voltage, ampere hour, watt hour, temperature, watts, cycles, current, ampere hour percentage recharge, watt hour percentage recharge, voltage change and current change) for almost all types of testing requirements have been built in.

Human Resource Development

Petroleum Refining

IIP organised 10 courses on Petroleum Refining Tehnology of various durations for personnel of various refineries.



Recognitions & Awards

Hari Om Ashram Prerit S.S. Bhatnagar Award for Catalysis (1993)	• Dr. G. Muralidhar, IIP

ENVIRONMENT & ECOLOGY

Growing human and animal populations, large scale industrialisation and expansion and intensification of agricultural activities with the attendant increasing demands for power and energy have put great pressure on our environmental systems. It is now recognised that this type of development cannot be sustained; natural resources and energy consumptions are to be kept within the carrying capacity of the eco-system. This would necessitate development of innovative technologies for enhanced material and energy effectiveness of production and consumption and a structural economic shift towards less resource intensive sectors.

Several CSIR laboratories are engaged in environment related R&D activities. Whilst NEERI has provided crucial S&T inputs for and played an important role in resolving national environmental issues/concerns and has been a path-setter for developing appropriate solutions for environmental problems, other laboratories like CLRI, CMRI, CRRI, IIP, ITRC, NCL, NGRI, NIO, NML, NPL, and RRLs have contributed significant inputs pertaining to their specific sectors.

Science

Genotoxicity of Hazardous Chemicals and Wastes

NEERI undertook an inhouse study to examine the genotoxicity, by measuring the DNA-damaging potential, of the extracts of soil contaminated with pesticides carbamate manufacturing industry. It was seen that carbaryl and alpha naphthol singly or in combination induced 69% in vitro DNA damage ($P < 0.01$) in human leucocytes as shown by the Fluorimetric Analysis of DNA Unwinding Assay (FADU). Experiments are now under way with cyclin D, and E antibodies to determine overproduction of cyclin in cultured mammalian cells after exposure to toxic chemicals.



Bioremediation for Decontamination of Hazardous Waste Disposal Sites

Bioremediation is becoming a preferred option in the treatment of chemical wastes and dump sites. Bioremediation of a contaminated site requires the availability of appropriate microorganisms and the balance of nutrient (C : N : P) that favour utilisation of target compound(s).

Under a World Bank funded project, a library of bacteria has been developed at NEERI for transforming a wide variety of chemicals including aromatics, polycyclics, halogenated aliphatic and aromatic compounds, as well as heavy metals like mercury. Bacteria have been isolated using polyaromatic hydrocarbons as substrate for constitutive and inducible degradative phenotypes to comprehend the role of inducer molecules

such as phenol, catechol, salicylate and benzoates. These studies have helped in designing consortia of bacteria for degradation of mixture of chemicals at hazardous waste dump sites.

Carrying Capacity based Socio-economic Developmental Planning

A study was sponsored at NEERI by Ministry of Environment & Forests for delineation of guidelines for evaluation and decision making related to overall regional development of NCR with appropriate environmental safeguards. The zones selected for planning included constituent districts of the sub-region in Delhi, Haryana, Rajasthan and Uttar Pradesh. The developmental planning processes involved generation of alternate scenarios within the assimilative and supportive capacities in the region.

Technology

Catalytic Converter for Auto exhaust Emission Control, and Diesel Particulate Trap

Technologies for two way non-noble metal catalytic converter for gasoline driven vehicles and a particulate trap for diesel driven vehicles developed at NEERI have been transferred to industry. Internationally available cordierite honeycomb monolith supports from different sources were examined and their surface area improved to the desired level by alumina washcoating. A crucial r-alumina washcoating process was also developed and standardized by NEERI. The catalyst was a perovskite type coated on the alumina washcoated support. Vehicle specific modifications in the catalytic converter(s) were incorporated using mass transfer, pressure drop and thermal gradient modelling to optimize the dimensions. The specific designs ensure minimum pressure drop across the converter, and adequate retrofitting for the existing Indian vehicles. The particulate trap comprises of baffles, aggregation chamber and a particulate collection system consisting of high efficiency multicyclone and rotary stream separation. The trap has an efficiency of over 65%. The plant for commercial production of the converter and diesel particulate trap is being established at Vadodara.



Desulphurization of Gaseous Fuels and Emissions

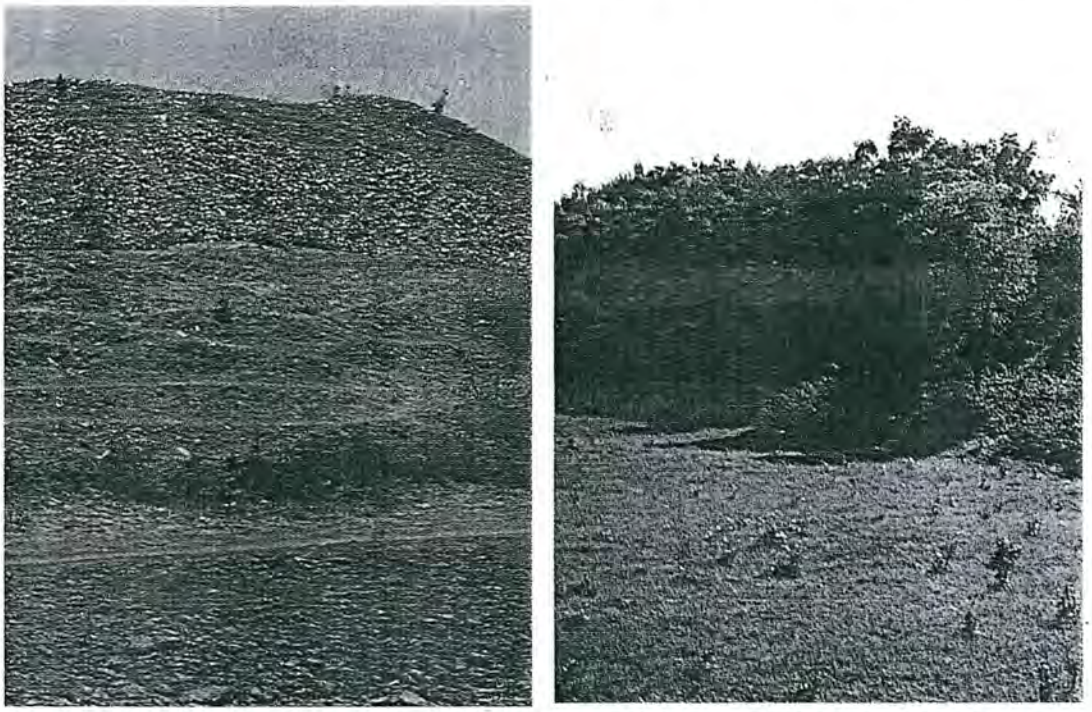
A chemo-biochemical technology for precombustion desulphurization of gaseous fuels and emissions containing hydrogen sulphide with concomitant recovery of elemental sulphur has been developed by NEERI under the sponsorship of DBT. In the two steps process H_2S present in fuel gas and emissions are selectively oxidized to elemental sulphur in the first stage by an oxidant which in the second stage is biologically oxidized for reuse, using a microbial culture also developed by NEERI. Experiments on desulphurization of refinery fuel gas and emissions

indicated that the H_2S from refinery fuel gas is removed with an efficiency of 99% selectivity, without effecting other constituents of fuel gas. Technology transfer for the chemo-biological process is under negotiation with two Indian refineries and several industries besides three international agencies in USA, Japan and Singapore.

Pilot plant studies on desulphurization of biogas have been taken up for a chemical unit with financial support from the MNES and a commercial proposal on the technology for treatment of tail gas from sulphur recovery unit at Mathura Refinery is being negotiated.

Bioremediation of Mine Spoil Dumps

An Integrated Biotechnological Approach (IBA) for bioremediation of mine spoil dumps developed by NEERI ensures reclamation within 3-4 years. The process appropriately blends spoil and organic waste(s) for the establishment of the plants microflora, inoculation of plants with specialized culture(s) of nitrogen fixing microorganism and strains of endomycorrhizal fungi for profuse root development and stress tolerance. The process is applicable for bioremediation of all types of mine spoil dumps with due modifications with respect to the mine dump characteristics, type of organic waste available in the vicinity, and microbial cultures. It is also a promising process for reclamation of wastelands.



Manganese Mine Spoil Dump – Barren (left) and Reclaimed (right)



Oil Spill Remediation & Treatment of Petroleum Refinery Wastewater by Microbial Consortium

Under sponsorship from DBT, a microbial consortium of well defined microorganisms, where the individual organisms perform designated functions, has been developed by NEERI for remediation of crude oil spills, and for pollution control of refinery wastewaters.

The two step process includes the application of alkali treated sawdust, as the first step to recover most (90-95%) of the spilled oil and biodegradation of remaining oil by using the bacterial consortium in the second step. The consortium constituents have been transformed with pro 'U' operon which imparts osmotolerance to the microorganisms and enables them to work under hypersaline/marine conditions as well. The bacterial consortium is also effective in the treatment of petroleum refinery wastewaters. The biotechnological approach thus is very useful for pollution control.

Dense-filling with Flyash

Work carried out by CMRI in collaboration with Ministry of Environment and Forests, Govt. of India, National Thermal Power Corporation, Singareni Collieries Company Ltd., Central Coalfields Ltd. and Damodar Valley Corporation has led to the development of a system of dense filling of underground mines with flyash and bottom ash. This method is expected to be a better and more cost effective alternative to sand stowing in underground mines to reduce subsidence, mine fires etc. More importantly the technique will enable the utilisation of flyash in large quantities.

Design & Installation of Common Effluent Treatment Plants (CETPs)

The Government of Rajasthan retained NEERI to design and install two Common Effluent Treatment Plants (CETPs) for 775 textile units at Pali. The work involves detailed engineering, construction, procurement, and commissioning of CETPs at Mandia Road (6.81 MLD), and Punyate Road (9.08 MLD) including the upgradation of the existing CETP at Mandia Road; training of operators; and operation of the full scale treatment plants for one year. NEERI completed its designs based on the evaluation of eight treatment alternatives through bench-scale treatibility studies. The construction of these plants has since been undertaken by the Rajasthan State Bridge Construction Corporation (RSBCC), and is scheduled for completion in June 1998.

High Rate Transpiration System (HRTS) for Wastewater Disposal



HRTS is an effective water treatment system that enables the soil to function as an active filtration device to renovate the wastewater through adsorption, ion-exchange and stabilisation of pollutants through microbial degradation. Further the soils installed with HRTS make very useful plant beds as the transpiration of plants grown on these soils make the system serve as a biopump and the plants consume the wastewater through evapo-transpiration. NEERI under a collaborative R&D programme with the Orissa State Water Supply & Sewerage Board designed and implemented the HRTS for treatment of municipal wastewater from Puri town to prevent sea beach pollution. The HRTS was installed in specially

designed ridges and furrows over 3 hectares, provided with coconut waste filter media and planted with saplings of Casurina and Acacia. This has led to improvement in scenic value of the sea beach and more importantly the prevention of the sea beach pollution.

Lime Sludge Waste Utilisation

Based on the test data with lime sludge of MPL and fly ash of Ennore Thermal Power Station (ETPS), two batch compositions have been optimised by CFRI for the manufacture of building bricks. Also the techno-economics has been evaluated for the same for two plants of capacity 30,000 bricks/day (2 shifts) each. Capital cost of plant has been computed to be around Rs. 130 lakhs and cost of production per thousand bricks is less than Rs. 1200 for the two batch compositions.

Utilisation of Fly Ash in Agriculture

Field experiments being conducted by CFRI over the past two years on the use of fly ash as a soil conditioner at the two sites in the vicinity of Bakreswar Thermal Plant (BKTPP) being built and the operating plant at National Thermal Power Corporation (NTPC) at Farakka were concluded. Results obtained from the field experiments conducted with different fly ash proportions ranging from 25 to 200 tonnes per hectare in the red and lateritic soils of Birbhum District (BKTPP) and alluvial soils of Murshidabad District (NTPC) respectively in West Bengal had clearly established the extremely beneficial effects of fly ash in significantly improving the yields between 20% and 60% of the crops such as paddy, maize, soyabean, mustard and potato, without any toxic effect. Such a beneficial effect is attributable to the changes in physical properties of the soil such as porosity, hydraulic conductivity and water holding capacity, besides the increased availability of nutrients. The results of the study on the residual effect of fly ash and new field trials on the cultivation of the crops have further established the beneficial effects of fly ash in agriculture. In view of the encouraging results, the Department of Science & Technology is sponsoring large scale field trials.



Inspection of Environmental Management Systems for Reports to Supreme Court of India

NEERI was called upon by the Hon'ble Supreme Court to inspect and report on environmental management systems namely for:

i. Impacts of Aquaculture Farming, and Remedial Measures in Ecologically Fragile Coastal Areas in Andhra Pradesh and Tamil Nadu.

ii. Impacts of Aquaculture Farming, and Remedial Measures in Ecologically Fragile Coastal Areas of India.

iii. Inspection Report on Pollution Control Measures Implemented at the Rourkela Steel Plant.

iv. Evaluation report in the matter related to the Effluent Standards for paper industry in the State of Uttar Pradesh.

v. Examination Report on Issue related to proposed Common Treatment Plants for the Cluster of Tanneries at Tangra, Tiljola, Topsia, and Pagla Danga in Calcutta, West Bengal.

vi. Examination Report on Feasibility of Setting up of Common Effluent Treatment Plant for cluster of Tanneries and Inspection of Existing CETPs in the State of Tamil Nadu.

vii. Inspection Report on Evaluation of Pollution Control and Environmental Protection Systems at M/s. Mardia Chemicals Limited, and M/s Mardia Street Limited, Vatva Ahmedabad, Gujarat.

viii. Inspection and Examination of the Water Supply System in Agra installed by UP Jal Nigam and operated and maintained by Agra Jal Sansthan, Agra.

ix. Final Examination Report on Common Effluent Treatment Plants (CETPs) for Cluster of Tanneries after Stabilization period, Inspection of Pretreatment Plants for individual tanneries, and Pollution Control in dry type of Tannery Operations in the State of Tamil Nadu.

Human Resource Development

Indo British Training Programme on EIA of Industrial Projects

The training programme was sponsored at NEERI by the Central Pollution Board and British Council, Mumbai for officials of the State and Central Pollution Control Boards. Objectives of the training was to build the capacity of participants for Environmental Impact Assessment of developmental activities.

Application of Statistical Methods in Environmental Science and Engineering



NEERI organised a workshop on Application of Statistical Methods in Environmental Science and Engineering during March 20-22, 1996 under DBT sponsorship. Participants were exposed to application of appropriate techniques for data collection and presentation, latest statistical methods for analysis and sophisticated software packages for data analysis and interpretation for environmental monitoring.

FOOD PROCESSING

The food processing sector has an important role in improving and sustaining agricultural productivity; reducing wastage of fruits, vegetables and other perishable food commodities and improving food availability both for domestic markets and exports.

CSIR's focus has thus been to provide S&T inputs that help to conserve food resources, raise levels of productivity, enhance value addition and boost the export worthiness of agroproducts. CSIR has one full-fledged institute namely CFTRI devoted to R&D for the sector while RRL-Jm., RRL-Tvm. and CSIR Complex Palampur have some R&D activities of value to the sector.

Science

Asperaginases Produced by Rhodosporidium torulides

Studies at CFTRI on characterization of an extracellular asperaginase of *Rhodosporidium torulides* exhibiting unique physico-chemical properties has shown that *Rhodotorula/Rhodosporidium* yeasts are quite unique biochemically – a knowledge important for the manipulation and application of these yeasts in industrial processes.

An asperaginase specific for L-asperagine was purified from *Rhodosporidium torulides* CBS14 to apparent homogeneity. The enzyme was associated with L-glutaminase activity (K_m 1.43 x 10^{-3} M for L-asparagine and 6.45 x 10^{-3} M for L-glutamine). The enzyme was found to be a homodimer with a subunit molecular mass of 87 kDa. Chemical modification of tryptophan residues significantly reduced both L-asparaginase and L-glutaminase activities of the enzyme, which was prevented by the presence of either of the substrates L-asparagine or L-glutamine. The pH and temperature optima for both activities were 6.35 and 37°C. The enzyme was serologically identical with the asparaginases of *Rhodotorula* and *Rhodosporidium* yeasts but was distinct from the asparaginase of *Saccharomyces cerevisiae.*



High Value Metabolites by Hairy Root Cultures

Hairy root cultures derived from transformed roots produced by agrobacterium rhizogenes infection are capable of producing high value metabolites which are important because of their ability to produce root derived phytochemicals for use as food colourants. Efforts of CFTRI to develop technology for the production of food additives on special reference to betalaines from *Beta vulgaris* and thiophene from *Tagets minuta* assumes a special significance since presently the R&D emphasis in the field is only on compounds such as anti-cancer drugs from *Catharanthus roseus, Hyosyemus niger* for propane alkanoid, Shikonin from hairy roots of *Lithospermum erythrorhizon* by this technology, whereas for food applications only ginseng biomass has been obtained by this technology.

Betalaines are useful as food colourants in place of synthetic dyes. Production of betalaines has been worked out and parameters such as elicitor induced production and enhancement of yields by manipulating the media constituents and inoculation conditions have been worked out. Other process parameters, such as rheology, mass transfer and production kinetics for growth and product formation have been studied. This approach will provide an international advantage due to the worldwide demand for natural food colours.

Hairy root culture technology is eco-friendly and can be adopted anywhere in the world independent of geographic locations and agro-climatic requirements. CFTRI's contribution will be towards understanding of growth and productivity in hairy root culture system.

Structure of Proteins/Enzymes for Food Processing Industries

Pectinolytic enzymes which account for 10% of total food enzyme trade are produced by microorganisms and higher plants, and find application in the fruit processing industry. Polygalacturonase [poly(1,4 alpha D galacturonide) glycanohydrolase E.C. 3.2.1.15] is depolymerizing pectinase that catalyzes the hydrolysis of alpha 1,4 glycosidic linkage of polygalacturonase chains in pectin, thus causing structural degradation. CFTRI has purified and characterized this enzyme from various fungal and bacterial sources and has found that polygalacturonases from the same source and different sources differ in their molecular size, pH optima and specific activity. An understanding of the structure and stability of these enzymes may lead to better applications of the enzyme in the food industry.

The development of a low cost purification protocol for polygalacturonases endows it with an immense potential as a molecular biology reagent. The characterization and purification polygalacturonase PG II could lead to cloning and expression of this enzyme for commercial exploitation.

CURCUMIN A Natural Non Toxic Antibrowning Agent

Browning of fruits, vegetables, fish and beverages is a major impediment for maintaing quality of products by the food industry during processing and storage. Many food products undergo enzymatic browning reactions during processing, which cause a change in colour, appearance and organoleptic properties, and thus have an important bearing on food quality.



Studies at CFTRI aimed at finding natural enzyme inhibitors that would provide a high degree of control at low concentrations, are cheap and non toxic with no adverse effect on the organoleptic qualities of the food, have shown that curcumin, the active spice principle of the commonly used condiment turmeric (*Curcuma longa* Linn) prevents browning. Curcumin at very low concentrations in solution prevents the browning of cut apple, potato and brinjal. Curcumin is also found to be a potent inhibitor of PPO purified from banana, pineapple and mushroom. The inhibition kinetics showed that it is a competitive inhibitor with a K_i of 2.7×10^{-6} M.

Edible Natural Food Dyes

CIMAP has developed and standardised bench scale processes for extracting colouring materials from plant sources which are safe as food dyes. The dyes are:

- Betacyanin, red dye from *Beta vulgaris* (Chukandar)
- Carthamin, red dye from *Carthamus tinctorius* (Safflower)
- Butein, yellow dye from *Butea monosperma*
- Xanthophyll, yellow dye from *Tagetes erecta* (Marigold)
- Violet coloured dye from *Daucus carota* (Black carrot)
- Capsanthin, deep carmine red from *Capsicum annum* (Chilli)

Food Formulations

Several food formulations were developed by CFTRI namely:

- Technology for malt based biscuits provides formulation for enteral food necessary in certain surgical and physiological stress conditions.
- Processing conditions have been determined for producing maize noodles with improved cooking qualities and reduced solid loss in processing.
- Formulation for a pulse based spice mixture for making soup mixes.
- Optimum values of soaking time, steaming and temperature of wheat for making wheat flakes.

Quick Cooking Rice

A process for cooking rice in two stages with a yield of over 75% has been developed by CFTRI. The quick cooking rice can be used as a base for the preparation of a variety of high quality, cost effective and nutritious convenience food products.



Decolorisation of Palm Oil

RRL-Tvm. has standardised a method of decolorisation of palm oil using kaolinitic clays from Kerala. The decolorising activity of these activated clays was higher (>75%) than that of commercial bleaching earth's (~60%). A detailed report has been submitted to STEC, Kerala, who had funded the project.

Chapati Making Machine

Design for an automatic machine for continuous production of 600 chapatis per hour has been optimised by CFTRI. The unique design enables rolling and baking of chapatis. The wheat flour dough is conveyed continuously to



Chapati Making Machine

the extruder and a fish tail die moves the sheet of the dough to a belt conveyor. The sheet of dough then passes through a rotary cutter and a circular shape chapati is baked on both sides in a baking chamber. The machine can be easily manufactured by an existing equipment manufacturer.

Services

Freeze Grinding of Spices

A freeze grinding unit with a capacity of 80 kg spice per hour has been set up by CFTRI which has provision to inject liquid nitrogen to attain specific grinding temperatures. The particle size of black pepper for essential oil distillation has been optimized in the unit.

Molecular Distillation Column

A molecular distillation column has been set up at CFTRI. This has (a) enabled the removal of free fatty acids from crude rice bran oil; (b) help develop a two step process for isolation of piperine from pepper oleoresin, with a piperine purity of 80% in the first step and 96% in the second; (c) high pungency chilli oleoresin with 13% capsaicin and a colour value of 30,000. Two methods, namely, high temperature short time (HTST) and blanching under alkaline conditions without resorting to the use of sulphur dioxide, have been worked out for obtaining dehydrated green pepper. Method has also been evolved to improve the colour of chilli and tamarind without loss of their important constituents. A procedure has been devised



for trapping and recovering basmati flavour from cooked basmati rice. The important flavour impact constituent has also been identified.

Testing and Analysis

CFTRI analyzed nearly 6000 samples of food material and products for conformance to food standards and assurance of quality received from the Directorate of Fruit and Vegetable Products of the Ministry of Food Processing Industries, Appellate Courts, Port Health Authorities, Directorate-General of Health Services, Industrial Enterprises and State Governments. Also lectures, aided by visuals, were conducted in collaboration with voluntary agencies for creating awareness among the public about health hazards of adulterants and contaminants in commonly used food articles.

Technical inputs were provided in response to more than 7600 enquiries in various subjects relating to Food Science and Technology from different classes of persons such as entrepreneurs, educational institutions, Government departments and private organizations.

Human Resource Development

Short Term Training Programmes

CFTRI conducted thirty-three two weeks programmes benefiting around 450 participants on aspects ranging from storage, processing and quality control of food grains to quality control of alcoholic beverages to developments in chocolate and sugar confectionery to preservation and packaging of milk based products.

CFTRI conducted another 10 programmes of 6-8 weeks duration for students from diverse universities on specific subjects such as Plasmid Profiling of Lactobacillus, Purification of phytase from yeast and gracillis, polysaccharides elucidation, pesticidal residual analysis etc.

Post Graduate/Doctoral Programmes

Twenty-two students were awarded the M.Sc. Food Technology degree and 14 Ph.D. degree.



Recognitions & Awards

Laljee Godhoo Nidhi Award – 1994 of AFST(I), Mysore	• G.A. Ravishankar • L.V. Venkataraman • T. Rajesekharan • G. Suvaranalatha • V. Siyatha • J. Sidhakar • L. Rajendran

HOUSING AND CONSTRUCTION

The national tasks in the Housing & Construction sector including Roads are stupendous. The role of R&D in the total endeavour is however limited to development of appropriate building materials, condition monitoring of structures and their distress diagnostics and rehabilitation, long span and high rise structures, architectural design of built spaces, pavement design, planning of transport systems, wind engineering etc. Four CSIR laboratories are exclusively devoted to R&D and S&T services for this sector namely, CBRI, CRRI, SERC-G, SERC-M, while significant R&D work related to building materials is being conducted at CGCRI and RRL-Bho.; six other laboratories also contribute to some R&D/S&T of relevance to this sector.

Science

Parallel Processing Techniques for Dynamic Analysis

Parallel algorithms for nonlinear transient dynamic analysis employing explicit and explicit-implicit time marching scheme have been devised by SERC (M). A parallel computer code has been developed for pseudo transient analysis to obtain nonlinear static response by integrating the dynamic equilibrium equations with fictitious mass and damping matrices. Parallel algorithms for the study of nonlinear response of large truss structures employing domain decomposition technique and design optimization of large truss structures have been developed employing subdomain optimization technique. This technique will be highly useful in providing cost-effective computation for large size FEM problems.

Mathematical Modelling of Fires in Buildings

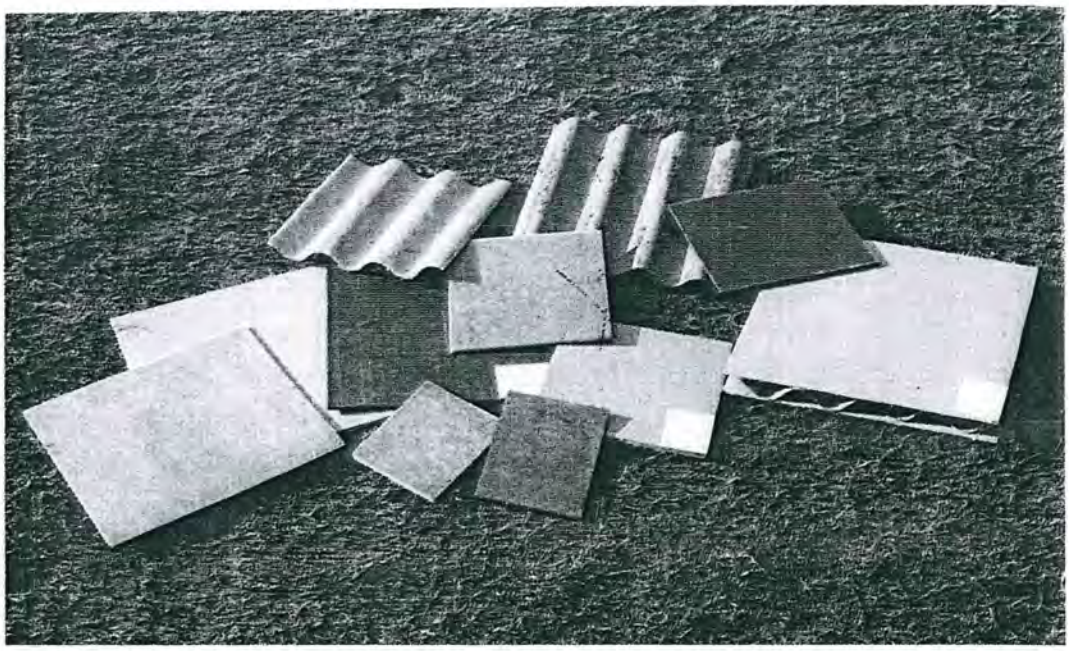
Mathematicall models, (CALFIRE and NEST) based on first principle, have been developed at CBRI to predict the consequences of a fire in a building. These models are data based computer programs in user friendly mode and contain data on physical, chemical, and thermodynamical properties of a number of combustibles as well as building materials used for construction.

CALFIRE has potential to study the behaviour of fires in a building much before it actually comes up. The model has been designed to measure the response of building and its fire protection systems to the anticipated size of a fire and also the human response and escape aspect.



Studies on Sisal/Polyester Composites for Building Application

There is great interest in using natural fibres as a reinforcement in polymer matrices and also in some cases as a replacement of glass fibres for making low cost composite building materials. Possibilities of using sisal fibre because of its high tensile modulus and low elongation at break point has been researched upon at CBRI. Surface modification of sisal fibre not only



Sisal Polyester Composites

improved the physico-mechanical properties but also shifted the failure mode from interphase controlled to the internal strength of the fibre/matrix.

An optimum system for particulate hybrid composite laminates with the help of filler, sisal fibre, glass fibre and unsaturated polyester resin was developed. The suitability of these laminates was assessed in relation to the requirements laid down by BIS for medium density fibre board (IS 12406 88) and high density particle board (IS 3478 66). The new composite has good physico mechanical properties and performance characteristics. The potentiality of combination of sisal and wollastonite as part replacement to glass fibre was also attempted. These developments have promising prospects in building industry for making new/alternate building materials such as roofing, wood substitutes and other low cost housing elements.

Technology

Building Bricks from Black Soil



The CBRI developed technology for production of building bricks for bulk constructions from inferior quality black soils has been licensed to two industries. It involves techniques for improving the congeniality of the inherent characteristics of these soils for moulding, such as plasticity, brittleness at high temperature etc. and facilitates adoption of mechanised/ semi-mechanised methodologies for bulk production of good quality bricks. The technology is specially suitable for black soils of Maharashtra, Gujarat and Madhya Pradesh which do not lend to moulding and firing.

Non-autoclaved Cellular Concrete Blocks

The cellular blocks developed by CBRI are made from flyash, cement lime and a foaming agent and are cured at atmospheric temperature and

conditions. The blocks exhibit low thermal conductivity, good fire resistance and lend better to sound absorption than to normal RC slabs. The blocks are easy and economical to manufacture and can be taken up conveniently for in situ production.

Geogrid Reinforced Pond Ash Retaining Wall

For the first time in India CRRI has successfully optimised a technique on the construction of a retaining wall (for Okhla Flyover) using geogrid reinforcement and pond ash (from Badarpur Thermal Power Station). This technique will lead to bulk disposal of pond ash, a waste material, by effective use in large scale civil construction works.

Polymer Modified Bitumen

A novel high performance polymer modified bitumen binder has been developed by CRRI. Although costlier than the conventional bitumen, its total life span is significantly higher and has improved engineering characteristics. The polymeric bitumen thus has a good market potential for applications at bus stops, road crossings, bridge deck and runway surfacings. The binder technology has been licensed to two firms.

Cement-Polymer Composite Coating System for Corrosion Protection

In a corrosion reaction the metal ions leaving the metal lattice are irretrievably lost due to oxidation. Suppression of the reaction is generally attempted by the introduction of agents which inhibit either the dissolution or the oxidation process. In the cement polymer composite coating formulation developed at CECRI the polymeric film itself inhibits the oxidation process through interaction or nullification of the electrons involved and enables corrosion protection. This composite coating system includes a top coat based on a polyblend of the constituent polymer which provides compatible environment with the cementitious material and necessary mechanical and physical properties. During experimentation a typical prestressing strand was coated with cement polymer system and tensioned to a load of 10 tonnes at a specially designed anchorage bed. Simultaneously uncoated strands were also tensioned in the same anchorage bed. Both the uncoated and coated strands were subject to periodic salt-spray over a period of 18 months. The coated strand remained in excellent condition whereas the uncoated strands are found to have corroded and snapped.



Services

Fifth National Get Together on Road Research & Its Utilisation

CRRI organised the Fifth National Get Together on Road Research and Its Utilisation in January 1996 at New Delhi. The get together received enthusiastic response from the highway engineering community with 400 delegates attending and sponsorship from 22 goverment, public and private

sector oganisations. It provided a national forum for exchange of views on road and road transport related issues and for disseminating and promoting road research findings, products developed and services offered.

World Inter Change Network (WIN) Node

Following the formal launching of the World Interchange Network (WIN) by the world Road Association in 1995, CRRI became a WIN node in early 1996, and published the first CRRI bulletin of WIN in May 1996. CRRI has also set up a Computer and Road Informatics Centre (CRIC) which is also responsible for World Interchange Network (WIN) node for exchange of road related information.

Wind Tunnel Investigations

High level capabilities, expertise and facilities have been developed at SERC (M) for carrying out investigations on wind sensitive structures such as buildings and structures and field investigations on wind characteristics, and dynamic response of towers due to wind.

An aero elastic model of 220 m tall multi flue reinforced concrete chimney has been tested to evaluate the along-wind and across-wind dynamic response due to wind, for Rajasthan State Electricity Board. Field investigations have been carried out for the assessment of wind loads on tower structures, terrain characteristics and structural responses.

Fatigue Analysis and Fracture Mechanics

Fatigue analysis and fracture mechanics studies were carried out by SERC, Madras for Oil and Natural Gas Corporation Ltd., on the cracked tubular



Fatigue Analysis and Fracture Mechanics Testing Facility at SERC-M



joint of an operational steel jacket platform in the Bombay High, for crack growth and remaining life assessment. The methodology involved determination of crack size, local analysis to predict the crack site stress field, determination of stress intensity factor for cracked geometry and crack growth prediction. Corrosion fatigue environment was simulated in the laboratory. The tests were conducted to comply with International Standards including monitoring of crack initiation and crack growth using a crack microgauge. Based on the studies of the crack growth, remaining life of tubular joint was assessed and monitoring procedures were recommended to ONGC.

Investigative Studies

CRRI carried out for the Chief Engineer, PWD (B&R), Jammu investigative studies on the causes of failure of 13 landslide prone stretches on the Arnas-Mahore Road in Udhampur, J&K. Based on the field studies CRRI suggested remedial measures.

Road Research Informatics Centre

CRRI has set up a Computer and Road Informatics Centre (CRIC) which is also responsible for World Interchange Network (WIN) node for exchange of road related information.

Human Resource Development

Training of Bhutan PWD Engineers

CRRI organised a training programme for PWD engineers from the Royal Government of Bhutan in the area of quality testing of material for construction of roads in hilly areas. The training comprised imparting academic knowledge and practical demonstration of laboratory testing procedures and practices. About twenty engineers took the training.

Refresher Courses

CRRI organised 12 refresher courses for practising Roads and Highways engineers on diverse aspects of design, construction, maintenance and quality control of Roads & Highways.



Recognitions & Awards

Member of Board of World Interchange Network (WIN)	• Dr. D.V. Singh, CRRI

INFORMATION PRODUCTS

In the last decade of this century Information Technology (IT) has emerged as a key determinant of development and there has been an explosive growth in gathering, processing, packaging and distribution of information. As a result, information has become a merchandisable commodity/product. CSIR is already generating ECF of the order of Rs.5 crore annually, from activities such as publication of Journals & Monographs, maintenance of databases, data banks and development of software & hardware etc.

Whilst two of the CSIR institutions, INSDOC and PID are directly contributing to this sector, other CSIR laboratories such as CDRI, CFTRI, CIMAP, CLRI, NAL, NCL are also significant contributors.

Science

Diffusion Models

The focus of studies at NISTADS in the area of Mathematical Modelling has been the processes of growth, diffusion and self-organisation within the area of science and technology. A non-homogeneous, non-uniform model of innovation diffusion, that gives weight to the adopters at different temporal stages and captures commonly observed fluctuations in new product diffusion was applied to obtain a forecast of Indian consumer durable products and growth trends in the enrolment of postgraduates and doctoral students in the natural sciences.

Technology

Library Automation

'GRANTHALAYA' a user friendly integrated library automation package conforming to international standards was designed and developed at INSDOC. GRANTHALAYA, has several unique and distinct features from other library automation softwares: (a) a novel data entry concept based on dictionaries which ensures data integrity and accuracy and permits data entry without a trained operator; (b) a totally modularised object-oriented paradigm system to suit varying requirements, (c) availability on a variety of platforms like single user DOS or WINDOWS, multi-user UNIX using a variety of RDBMS platforms such as INGRES, ORACLE and even a LAN version running under Novel Netware or TCP/IP environment. GRANTHALAYA due to its versatility holds the potential of emerging as one of the preferred advanced library automation packages especially in India.



Multi-Media Databases

INSDOC has developed in-house capability for handling multi-media databases involving textual, video, audio and multi-lingual data for a wide spectrum of applications e.g. preparation of photo- identity cards, educational kits, electronic encyclopaedic publications, presentations etc. One of the projects

undertaken by INSDOC was for preparing electoral photo-identity-cards for 12 assembly constituencies for the state of Delhi covering about 12 lakh voters. A database of voters was prepared in Hindi and English, and this data was then merged with the image of voter captured on the computer using an in-house designed sophisticated software. The file was then used to prepare (print) an identity card of the voter.

Electronic Publishing

PID has acquired the expertise and facilities for processing of data through the premastering and mastering stages and recording of full text and bibliographic databases for production of CD-ROMs. Under a collaborative project 'Asian Health, Environment & Allied Databases (AHEAD)' sponsored by the International Development Research Centre (IDRC), Canada. PID has been entrusted the management of the international consortium AHEAD. AHEAD has brought out CD-ROMs titled Wealth Asia and Environment Asia on health and environment related information respectively. Besides inhouse applications PID offers CD-ROM publishing services to external organisations.

NUCSSI on CD-ROM

National Union Catalogue of Scientific Serials in India (NUCSSI) was the first major database created at INSDOC on a CD-ROM format. It lists 38000 serial titles available in about 350 libraries of academic and research institutions and industrial R&D units. The CD-ROM database has been found to be very helpful reference for librarians for co-operative acquisitions, resource sharing and library lending.

PID Journals on Internet

Electronic publishing has led to a shift in S&T communication from the print media to online dissemination of information. PID has also made a start in this direction. Under an agreement signed with Bioline Publications, UK, three of PID's journals, viz. Indian Journal of Biochemistry & Biophysics, Indian Journal of Experimental Biology, and Indian Journal of Marine Sciences were made available for on-line distribution on Internet. While the contents lists and abstracts will be available free of cost, full text and graphics are to be paid for. **Web Site Address: http:/www.bdt.org.br/bioline.** It is planned to put the remaining PID journals on the Internet in a phased manner.



Enlargement of PID's MAPA Database

A bilateral collaboration between PID and Commonwealth Agricultural Bureau International, UK (CABI) has been initiated for enhancement of coverage of literature relating to medicinal and aromatic plants databases. Under this collaborative arrangement, 300 records annually are exchanged each way by CABI and MAPA database.

PID is the national node for Asian and Pacific Information Network on Medicinal and Aromatic Plants (APINMAP) in which 14 countries from the Asian and Pacific region are participating. Each country contributed data to the APINMAP Integrated Bibliographic database maintained at the APINMAP Network Centre based in Los Banos, Philippines. PID contributes Indian and Japanese data from the MAPA database.

Electronic Office

It is estimated that about 50,000 offices in India are likely to become 'paperless' through the use of electronic systems. To accelerate this conversion INSDOC has developed an electronic filing system that facilitates quick and faster retrieval of any document filed.

Services

Information Dissemination to S&T Community

Keeping in tune with its endeavours for timely and effective S&T information dissemination through the publication of scientific/technical journals, PID during the year launched its new bimonthly, the Journal of Intellectual Property Rights. Designed to create awareness of Intellectual Property (IP) importance in the new regimes of global liberalizations and also promote patent literacy among the S&T communities, the journal carries articles on all IP related aspects – Patents, copyrights, trademarks etc.

Further to widen its reach to users, PID has three of its journals on the internet for on-line distribution. Also effective June 96, exclusive Chinese editions of two of PID's journals viz Indian Journal of Chemistry section A and section B are being brought out through an arrangement with a Chinese publisher.

Electronic Library

A Pilot Electronic Library developed at INSDOC is a storehouse of information with over 6000 foreign journals acquired in electronic form including 2142 in full text and the rest with abstracts of articles, besides 360 IEE/IEEE conference proceedings, about 725 IEEE standards and colloquium digest, US patents since 1990 etc. Based on this information resource, INSDOC now offers several new information dissemination services of value not only to researchers but to corporate sectors as well viz.: Standing Order Abstracts Service (SOAS); Chemical Abstracts Keyword Index Service (CAKIS); Patent Watch Service (PWS); Competitor Watch Service (CWS); Global Tender Watch Service (GLOBTEND); and Full Text Journal Service (FTJS).



S&T Publishing Facility

PID is equipped with all essential facilities required by a major S&T publishing house. In addition to well-equipped Photocomposing, Printing, Designing, Graphic Art, and Photography and Production Units, PID also has a modern

desk Top Publishing Unit. The DTP unit has an advanced imagesetter system comprising Chelgraph 1BX-25402 imagesetter, Agfa Horizon Colour scanner (A3) and Agfa Rapline 43 automatic processor. These facilities are being used for producing high quality camera ready pages and scanning of illustrations for books, monographs, reports and other S&T literature.

Electronic Publishing

PID has embarked on the futuristic technology of electronic publishing through production of CD-ROMs. It has facilities for processing of data through the premastering and mastering stages for production of CD-ROMs. Information in the CD-ROM products can be retrieved quickly with the help of a built-in information retrieval software. PID is now in a position to undertake CD-ROM publishing for other organisations also.

Human Resource Development

S&T Communication

PID in collaboration with BITS, Pilani has launched a programme for manpower development in the field of S&T communication. PID for this purpose has been recognised as an off campus centre of BITS and offers the faculty and supervisory experts for academic courses. The programme comprises enhancement of academic qualifications and professional skills of personnel engaged in S&T communication jobs. During the year three scientists of PID earned the M.Phil. degree in S&T Communication and Journalism. Also short-term courses were conducted for training in writing/editing science articles and technical reports, design and illustration of scientific literature and herbarium management techniques.

Training Programmes

Several short-term courses on computer-applications to library and information activities, viz. CDS/ISIS, WINDOWS, Bibliometrics and office automation were organised by INSDOC. A number of attachment training programmes with course component and schedules customised to suit the trainee's requirements based on specific professional background and experience were also organised. A total of 33 training programmes were organised during the year for nearly 460 trainees including foreign trainees sponsored by WHO, SAARC countries and British Council.



Recognitions & Awards

NCSTC's National Award for popularising science	• Shri Dilip M. Salwi, PID
NCERT Award for Children's Literature	• Shri T.P. Pathak, PID

LEATHER

Leather industry has been at the centre stage of India's initiative to enhance exports, generate decentralised employment and promote development of rural areas. However the impressive contributions of the leather sector have not been without adverse effects on the environment and ecology. Also the cost advantage hitherto enjoyed by the sector is no longer a winning tool in the demanding global market place. These considerations, have thrown up newer challenges for the sector for which S&T holds the potential to provide the solutions.

CSIR contributes significantly to the entire leather sector with R&D emphasis on cost effective green technologies. It maintains the world's largest leather research institute in the Central Leather Research Institute (CLRI) at Madras. Over the years CLRI has emerged as a dependable source for technology and services for the Indian leather sector.

CLRI has launched several programmes at the field level with credible technological outcomes. Consequently it's credibility and connectivity within the sector are very high. In recognition of these endowments, CLRI has been designated as the nodal implementing institution for the Leather Technology Mission (LTM) for sustainable development of the Indian Leather Sector. The Mission is designed to bridge the gap between the organised and unorganised sectors of the industry. The Mission has started making tangible impact on the Indian leather industry through its development/extension activities, human resource development and engineering inputs for modernisation. Under the aegis of the Mission fifty-eight projects have been commissioned at twenty-three locations in ten states. The contributions and accomplishments of the Mission programme are covered in the write-up for the sector.

Science

Molecular Understanding of Tanning



An insight into the structural changes imposed on collagen by chromium in tanning is fundamental to a better understanding of the phenomenon on molecular basis. Accordingly various Cr(III) species of salts, were reacted with rat tail tendon (RTT) collagen and the relative stability imparted to the collagenous matrix against enzymatic attack and heat was studied. The results obtained revealed that long range ordering in collagen as well as the thermodynamic and kinetic properties of the collagen – Cr(III) interactions are strongly influenced by molecular structure of Cr(III) species. The interaction of chromium with proteins using bovine serum albumen was studied with a view to validating the reported carcinogenicity of Cr (V). Studies reveal the formation of stable EPR species and substantiate that Cr(V) induced abnormalities in biosystem.

Technological Upgradation of Carcass Recovery Centres

Low cost and viable fallen carcass recovery centres earlier designed and developed by CLRI have been actively propagated, both under the LTM and IRDP. Four centres, one each in the States of Tamil Nadu (at T. Kallupathi), West Bengal (at Kalyani) Madhya Pradesh (at Sehore) and Gujarat (at Tranaja) have been commissioned and made fully operational. The four centres together have a capacity to process 5000 carcasses/year and provide on-job training to about 30-40 flayers and local youth. The technology package provided by CLRI ensures effective byproduct recovery and waste-water treatment. Also to ensure quality of hides and skins produced, a programme for animal health care for skin defect minimization, was organised as an allied activity. The animal health care programme was launched in select villages of Nellore district of Andhra Pradesh and deworming and vaccination of animals carried out successfully.

Improved Bag Tanned Leather

CLRI has developed a new process of bag tanning. The process enables uniformity in tanning and yields wrinkle free leather which lends itself easily to cutting and glazing. The process is easy to adopt and gives 30% higher yields. The other features include reduction of process time by nearly twenty days and lesser water consumption for tanning.

Leather Processing Technologies

i. **Full vegetable upper leathers:** By effecting suitable modifications in the process conditions of technology developed CLRI has been able to standardise the process technology for producing fully organically (mineral free) tanned upper leathers possessing good hydrothermal stability, softness, dyability and strength characteristics.

ii. **Washable suede garment leathers:** Process technology for production of suede leathers has been suitably modified in respect of the retaining, dyeing and fatiquoring operations to produce soap washable suede leathers. The technology is ready for commercialisation.



Chrome Management

A major concern of the leather industries is cleaner leather processing that helps in the pollution abatement and its management. CLRI has developed various techniques/processes for chrome management for suitable adoption under varied conditions by the leather industry.

i. Zero-waste chrome tanning: A near zero-waste chrome tanning technique develop which allows for chrome recovery/reuse and has been demonstrated in two tanneries. This technique ensures 99% recovery and reuse of chromium. High exhaust chrome tanning systems present a viable option for overall reduction in chemicals cost (Rs.2000/tonne) and for achieving better environmental benefits. A full scale demonstration plant is being established for chrome recovery/reuse by a group of tanneries in Bangalore. Tanneries at Calcutta, Kanpur and Jalandhar have also been selected for implementation of the technology.

ii. Pickle free chrome tanning: Pickle free chrome tanning systems have been developed using aldehyde based products. Elimination of pikcling in the tanning process, besides leading to significant reduction in TDS enables higher uptake of chromium.

iii. New chromium-aluminium syntan: A new chromium-aluminium combination syntan – CLEARTAN AL and basic chromium sulphate – CLARICHROME have been developed. The process know-how has been demonstrated by CLRI to the licensee at 1 kg/batch level in the laboratory and in the pilot plant at 100 kg/batch level.

Novel NMR techniques

For the first time in India, industrial application of NMR micro imaging have been demonstrated. Novel NMR technologies for imaging of materials including diffusion of fluids into skins as well as new NMR probes have been developed.

Services

Eco-sensitivity Testing of Leather Chemicals

A national facility for PCP (Penta chloro phenol) testing for leather and leather goods set up at CBT under joint collaboration of the CLRI, Council for Leather Exports and Indo-German Export Project has been commissioned. The PCP test facility incorporates high precision micro analytical methods involving gas chromatography for PCP quantification. The facility basically caters to the needs of exporters of leather goods.

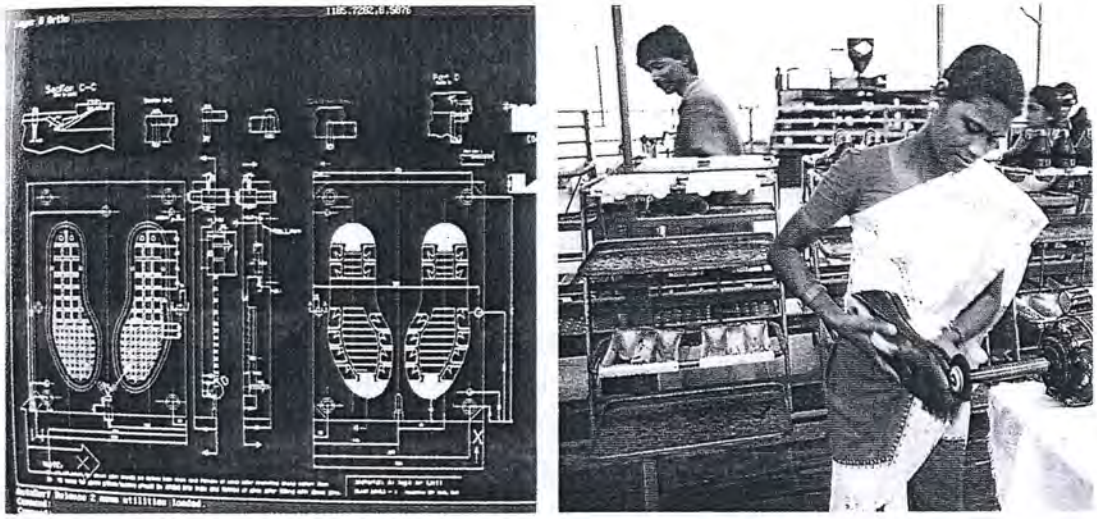


However, the recent ban on benzidine and arylamine based dyes by Germany has necessitated the establishment of a dedicated state-of-art laboratory for testing/analysis and monitoring the ecosensitive chemicals. CLRI is setting up such a facility with proactive capability to provide alert systems to the industries on possible ban of chemical substances in leather trade. In collaboration with the CSMCRI, a test rig based on reverse osmosis to clean up contaminated ground water has been fabricated for use in the services by the centre.

Product Design and Development

CLRI has built-up fashion forecasting capabilities. For the first time, in the MODEUROP Congress, colours and leathers from India have been included in the fashion forecast.

A Centre for Leather Apparels and Accessories Development (CLAD) has been established at CLRI and dedicated to the nation. The Centre has computer aided design capability for garment and leather goods. The Centre has already given several creative designs to the industry. The computer aided design facilities at the SATRA accredited laboratories for footwear is being increasingly used by the industry.



Leather Footwear – CAD Design and Training

Information Dissemination Activities under LTM

Three workshops were conducted during the year:

- At Warangal (AP) to promote interaction amongst tanners for implementation of ecofriendly technologies;
- At Madras alongwith KVIC on new developmental concepts for decentralised footwear production;
- At Madras on Short and Long Term Strategies for pollution prevention and remediation for North Arcot Tanneries.

Tannery Waste-water Treatment

Recognising that tanneries in Tamil Nadu and West Bengal were facing threats of closure, CLRI formed a special task force to evaluate the status of ETPs and CETPs of tanneries located in the North Arcot district of Tamil Nadu. Based on the studies a road map to achieving the requisite environmental standards for tannery wastewater over a period of 5 years was worked out.



TNO-CLRI Cooperation Programme

The TNO-CLRI cooperation programme yielded several technological outputs by way of technical demonstration of chrome recovery (reuse plants), closed pickle and loop system for near zero waste chrome tanning and technologies for coloured bricks from chrome sludge. Besides a pilot plant for upflow anaerobic sludge blanket (UASB) treatment of tannery effluents was set up. This has enabled the development of designs for UASB bioreactor for cluster of 18 tanneries.

Human Resource Development

Modular Training in Processing

Eleven modular training programme in leather processing covering four modules namely beam house operations, tanning, wet-finishing and finishing operations were organised.

Training in Leather Products Design

CLRI is a major contributor to National Leather Development Programme component Human Resource Development for the sector through innovative training and related programmes CLRI imparted training to about 550 students and others during the year.

Diffusion of Improved Technologies for Chappal Making

Traditional techniques employed by artisanal families for chappal manufacture were studied and improvements identified and technologies developed for improving quality standardisation for Kholapuri chappals. Lasts and templates were developed and a pilot production was organised at Athani with CLRI trained artisans. About 400 pairs of chappals were fabricated and comfort assessment made using wear trials. Modifications to the lasts and templates made with feedback obtained. Over 200 families at Athani have been trained.



Recognitions & Awards

Fellow of National Academy of Sciences	• Dr. N. Chandrakumar, CLRI
Zoological Society of India Golden Jubilee Young Scientist Award	• Shri K. Purna Sai, CLRI

MACHINERY & EQUIPMENT

CSIR has been in the forefront of developing machinery and equipment specifically to suit the processing use of local raw materials and skills. Whilst CMERI and its four MERADO centres are specially devoted to this sector the other laboratories contributing to the sector are CECRI, CFTRI, NAL, RRL-Tvm.

Science

Design of Computation Fluid Dynamics Software starting from basic principle and generation of requisite design data software was developed to assist in fluidised bed dryer for oil seeds and expanded extruder for oil seeds.

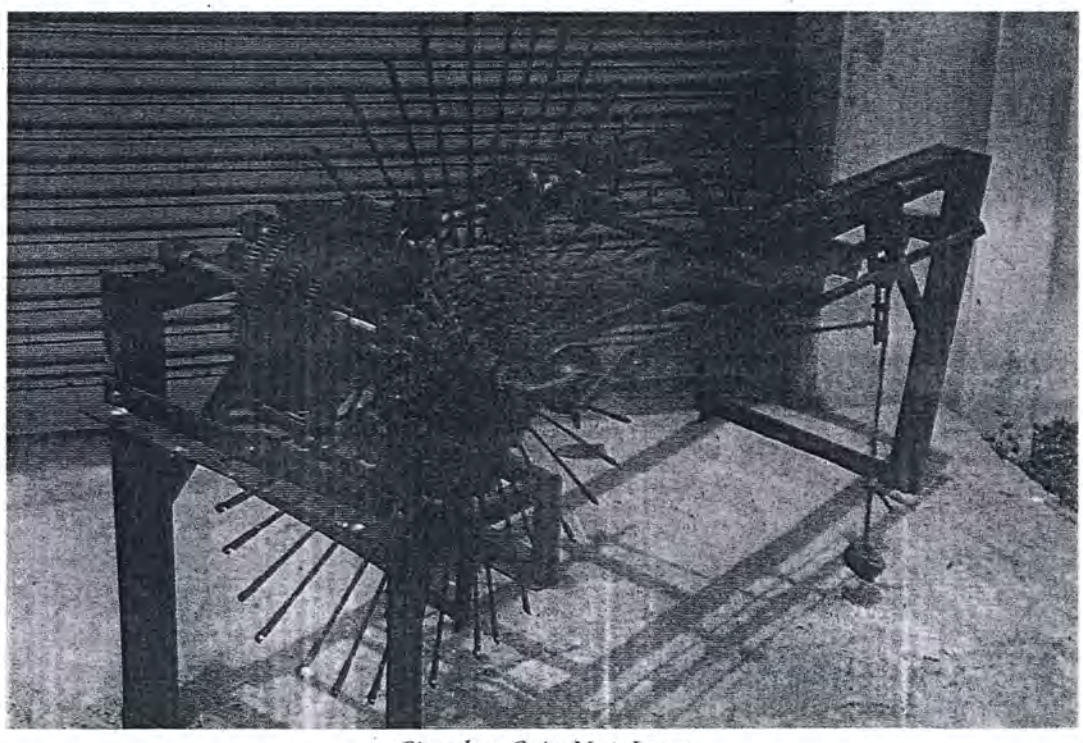
Technology

Circular Coir Mat Loom

MERADO, Cochin has developed a mat making machine that weaves circular mat around rods arranged radically and a rod pulling machine that pulls out the rods and feeds the coir ropes in their place. The machine significantly enhances the productivity and quality of the product. The development was sponsored by the Coir Board.

Universal Fibre Yarn Machine

Rope making from agricultural byproducts is done manually all over the country. CMERI has developed a machine that can be used with any natural fibre to yield yarn of better quality and strength. Besides licensing the technology to a firm, CMERI itself is fabricating 100 machines for distribution and field testing in different parts of the country.



Circular Coir Mat Loom



Palm Oil Twin Screw Press

MERADO, Madras has developed a twin screw press for extraction of Palm Oil with a nominal processing capacity of 5 tonnes of fresh fruit bunches per hour. The project was sponsored by the Technology Mission on Oilseeds and Pulses and the knowhow has been handed over to them for further dissemination and licensing.

Mine Support System Using Rock Bolts

Mine support systems using rock bolts as primary support have been designed for various geomining conditions at CMRI. The support is faster in installation and cost effective compared to conventional supports. Stability of a pillar at the mine below the railway line has also been evaluated for extraction of ore in the vicinity of the pillar at Balaria Mine of Hindustan Zinc Ltd.

Services

Residual Life Assessment

CMERI has accumulated a wealth of knowledge and experience over the last three decades in the application of Reliability and Failure Analysis and Residual Life Assessment useful for predictive/preventive maintenance, repair, retirement or life extension of critical power/process plant components. CMERI provided these services to various power stations, steel plants, a number of process plants and other units around the country.

Cylinder Testing Accreditation

A multifaceted infrastructure for quality assurance through testing, evaluation, calibration and standardization was built up under the aegis of CMERI, and four forward MERADO Centres at Pune, Ludhiana, Madras and Cochin. In recognition of the level of competence of CMERI, it was authorised to act as an accredited agency for Cylinder Testing Certification by the Chief Controller of Explosives, Government of India, Nagpur.

Batteries Life Cycle Testing System



A fully automatic battery life cycle testing system consisting of five channels for testing 12V batteries up to 250A has been acquired by CECRI. This is a computer controlled system with comprehensive easy-to-use software package. There are several limit conditions (e.g. time, battery voltage, ampere hour, watt hour, temperature, watts, cycles, current, ampere hour percentage recharge, watt hour percentage recharge, voltage change and current change) for almost all types of testing requirements.

Human Resource Development

Training Programmes

CMERI organised several specialised programme for practising professionals for condition monitoring, 2-D Modelling using Auto-CAD, Engineering Dimensional Metreology, Vector Algorithm Language (VAL) programme for Robotics etc.

MINERALS, METALS & MATERIALS

India is one of the few countries endowed with abundant natural mineral resources and ranks amongst the largest producers in the world of iron ore, chromite, manganese ore, mica etc. The development of new and advanced tailor made materials would greatly influence human life and activities in the years to come. The laboratories primarily engaged in R&D for the mineral sector are NGRI, NML, RRL-Bho., RRL-Bhu. and RRL-Tvm.; for metals R&D the laboratories are CECRI, NML and RRL-Bhu. and for new materials CECRI, CGCRI, NAL, NCL, NML, NPL, RRL-Bho. and RRL-Tvm.

Science

Simulation of Fluid Flow in Steel Making Concast Tundishes through Water Model Studies

Detailed studies on the flow patterns in steelmaking concast tundishes were carried out at NML on a full scale model of a tundish used in a mini-steel plant covering investigation on both open entry (OEN) and submerged entry (SEN) modes of operations. A device mitigating the formation of vortex at the entry on the fluid surface was also developed, to prevent suction of air into the steel and thereby in the oxidation which would affect the quality of cast billets. A simple and inexpensive device was fabricated and simulations carried out thereon to increase the mean residence time. Detailed investigations were carried out for the first time on the pressure head distribution in the downstream entry (both SEN/OEN) as well as the tundish bottom in order to obtain approximate velocities of flow in vertical and horizontal directions and simulate shrouding of the downstream with inert gas as is practiced in the steelmaking tundishes. Result of the above experimental studies help in recommending appropriate measures for control of operating practice to industrial plant operators for obtaining quality cast steel products.

Statistical Physics Random Agglomeration

Science of random fractal agglomerates plays an important role in several areas like catalytic/electrocatalytic reactions, porous electrodes and super capacitors wherein a measure of the effective surface areas of a random agglomerate is an important parameter. Studies at CECRI have established a remarkable relation between the "volume" measure of a random agglomerate and its "surface area". Derived through elegant use of the "functional derivative" the relationship was successfully applied to a prototype of nucleation and growth modes obtaining concrete results for 1-D, 2-D, 3-D random agglomerates. This achievement provides rigorous measures for these random agglomerate areas in place of hitherto available empirical formulae.



Hydrodynamics of Coarse and Heavy Particles in Flotation Columns

RRL-Bhu. assessed the effect of different types of wash water distributors in terms of hydraulic entrainment of fine particles into the froth and overloading of the froth

in the cleaning zone. Different types of spargers were designed and used to avoid entainment loss of fine bubbles to the tailing system. Injection of water was observed to eliminate the checking problem due to coarse and heavy particles in the tailing line.

High Grade Synthetic Rutile

Synthetic rutile is presently made in the country using benelite process which involves the use of almost 3.5 tonnes of Hydrochloric acid per tonne of synthetic rutile necessitating very expensive acid recycling for pollution control RRL-Tvm. has devised an environmentally friendly route that lowers the acid requirement by almost 70-80% besides generating a non polluting iron oxide by product. The process involves high temperature metallisation of ilmenite in a Rotary Kiln followed by aeration leaching and solid-liquid separation by the use of hydrocyclones and belt filters. The process has been scaled up from laboratory and bench scale to a 3 TPD pilot plant set up at the user industry premises. Based on the data generated feasibility and design study for a commercial plant has been prepared.

Beneficiation of Gold Ores by Column Flotation

NML has established the amenability of flotation column for beneficiation of gold ores through the excellent reproducible metallurgical results obtained in the laboratory trials on an in-house designed 75 mm diameter column. The column was tried at BGML with highly appreciable gold grade and percentage recovery of gold in comparison to their conventional flotation cells. Subsequently, NML took up the design development of a pilot flotation column of 0.5 meter diameter under sponsorship from BGML. The pilot plant trials yielded a recovery rate of 85% with gold concentration of 60-80 gms per tonne (against the feed concentration of 2 to 3 gms per tonne of gold ore). This confirmed the results achieved on the laboratory scale trials on the 75 mm diameter column. NML further optimised all process parameters to obtain 60-80 gms per tonne gold concentration. Subsequent batch cyanidation trials for final extraction of gold also yielded excellent gold recoveries with nearly 30-40% savings in sodium cyanide consumption. NML has highlighted the benefits of adoption of column flotation to M/s BGML for their operations.



Beneficiation of Low Grade Graphite by Column Flotation

Low grade samples from Tumudibandh, Rajunagfere and Sargibahal mines have been tested at RRL-Bhu. both on conventional cells and column flotation to compare the flotation performance for its adoption whilst column flotation gave out put product with 90% FC from feed material containing 32-33% FC at 90% recovery of graphite values in single stage, the novel flotation column gives much lower grades and recoveries.

New Engineering Materials

Sol-gel techniques developed by NPL have been successfully employed to develop silicon-carbide incorporated carbon-carbon composites. Further, silicon-carbide

whiskers and silica-monoliths have been developed for variety of applications including catalysts.

High Temperature Superconducting Wires/tapes

Work carried out at NPL has resulted in the success of fabricating superconducting tapes upto 5 meter length having critical current density (Jc) value of about 2000 A/Cm^2. Multifilamentary tapes upto 10 cm length have been fabricated with Jc of about 1000 A/Cm^2.

Stainless Steel Powder

NML developed a special chemical process for making stainless steel powder (18.8 grade) from stainless steel scrap. The process has been transferred to two entrepreneurs. Paint grade stainless steel powder was also specifically developed for a client in Hyderabad.

Phosphogypsum for Production of Plaster of Paris

Process for beneficiation of phosphogypsum to mineral grade gypsum and its subsequent conversion to plaster of Paris standardised by CGCRI has been licensed to industry. The laboratory has also designed the beneficiation unit and special plaster calcinator of 500 kg capacity. Phosphogypsum, the toxic by-product of phosphate based fertilizer industry discarded as waste is an environmental hazard. This development not only contributes to mitigate the environment pollution caused but more importantly helps in supplementing the depleting resource of selenite for production of cement and plaster of Paris.

High Alumina Ceramic Fibres

High alumina short length ceramic fibres are high temperature insulation material used in heating systems where the conventional alumina-silica fibres cannot be used. Under sponsorship of National Laser Programme (NLP), CGCRI has developed novel methodology for production of these fibres through low temperature sol gel route. The method dispenses with the normal use of organic materials/polymer for fiberization of the sol gel and generates the gel fibres in the form of a thin mat that retains its structure on calcination at elevated temperatures, despite formation of polycrystalline short fibres. The process has been transferred to BEL and some other industries have also envinced interest in availing it.



Alumina Ceramics

A multi step process for production of alumina for abrasive applications using a novel mixed seed composition and drying gels under humidity conditions was developed at RRL-Tvm. under sponsorships from industry. The work is the subject matter of two patent applications that have been filed.

Diamond Powder Incorporated Metal Matrix Composite

Diamond powder incorporated metal matrix coated discs are primarily used for

polishing of natural/synthetic diamonds and other precious stones. They also find applications in tool inserts, audio speakers, X-ray windows, heat sinks and heavy automotive and other hi tech areas. Presently, these discs are imported. CECRI has developed an indigenous process technology for preparation of these discs at competitive costs. The process provides for partial encapsulation of the diamond particles occluded in the nickel electro deposits, whereby the projected part of the occluded diamond particles alone provides the required cutting action. Process also enables controlling of the amount of diamond powder particles in the nickel deposits to achieve desired properties, since too low a powder content causes the loss of mechanical property and too high content causes roughness and wastage of the coating.

The process with minor modifications in pre-treatment, operating conditions, cell design etc. can be extended to obtain any powder incorporated metal matrix composite electro deposits. In particular, for the development of metals matrix composite cutting incorporating diamond powder and cubic boron nitrite for tools that can yield enhanced productivity in metal working, material production grinding and finishing, rock cutting, precision cutting and machining. This is a custom oriented process development.

Services

Ultra-pure Nano-crystalline Alumina

Under a collaborative project with Tata Steel and NML alumina powder with 99.95% purity and size of less than 0.5 microns has been produced at the rate of 2.5 kg/day. The alumina powder has been synthesized through the Sol-Gel route with the recovery of alcohol used in the process and its recycling.

Component Integrity Evaluation Programme

NML initiated systematic and comprehensive studies for identification and quantification of accumulated creep damage and estimation of the remaining life of popular grades of steel. This has enabled the development for the first time of a new method based on threshold stress concept to be proposed for RLE of components.



Pollution Control and Waste Utilisation in Metallurgical Industries

NML has been constantly working towards achieving an integrated solution to the pollution problem, especially with respect to suspended particulate matters (SPM) from the cast iron foundries in our country. Typically in coke fired cupolas in the cast iron foundries of the Howrah area in West Bengal, the average suspended particulate matter (SPM) level in the exhaust gases is ten times higher than the permissible limit. Under a project founded by the CPCB Delhi, NML carried out investigative studies and successfully optimised better cupola designs with improved energy efficiency and devised compatible pollution control systems for pollution abatement in foundries. In November 1995, NML set-up a demonstration cupola with pollution control plant at foundry in Howrah, based on the optimised design,

and the plant successfully achieved a SPM level of below 120 mg/Nm^3 in the cupola exit gases as against the SPM emission norm of 150 mg/Nm^3 set by the CPCB, Delhi.

Refractory Materials Test

A new facility for testing compressive creep at temperatures upto 1400°C has been created at CGCRI. The elaborate testing procedure facilitates getting insights into salient parameters of the samples such as load bearing capacity of the refractory material with respect to quality of raw material and techniques for development of the refractories.

Technical/Engineering Ceramics

Three important equipments have been added to the service facilities' pool at CGCRI. These are:

- 20 kN low cycle fatigue testing machine (INSTRON, UK) under DST, GOI funding.
- 5 litres evaporation per hour Spray Drier for aqueous system with evaporation rate of 5 litres per hour.
- 1 kN Indentation tester (INSTRON-WOLPERT, Germany) gifted by Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH, Germany.

Separation of Fines in China Clay

RRL-Tvm. undertook sponsored studies on hydrocyclone for classifying china clays at ultra fine size ranges (<55 mm) with the aim to replace the industry's batch settling pits. Based on the results, a circuit of 40 numbers of 25 mm hydrocyclones has been commissioned in the clay separation plant of the sponsor which has since been giving successful performance.

Calibration Facility

A highly sensitive detector spectral response calibration facility using a monochromator based spectral comparator (350 nm to 1100 nm) has been established at NPL.

Indian Reference Materials

NPL has completed preparation of Certified Reference Materials (Indian Reference Materials) of Fluoride and Nickel in high purity water. Stability of these solutions with respect to container materials and storage were studied in detail and optimum conditions worked out. Following through analytical evaluation of these solutions by various sophisticated techniques available, these solutions were field tested by thirteen CSIR laboratories and two public sector laboratories for measurement of concentrations of the elements at different time intervals. These had been formally released and are now being made available to user organizations. Work on preparation of three other reference materials viz. nitrate in high purity water, silicon powder for X-ray diffraction and infant milk powder is being carried out.



New National Facilities Setup (Proof Load Test)

CMRI has been extending testing, evaluation and consultancy services to the mining companies and mining equipment manufacturers in India and abroad dealing with explosives and accessories, mine ventilation and safety equipment, roof supports, personnel protective equipment, flame proof and intrinsically safe equipment, electrical cables, mining and allied industrial components, wire ropes, cage and suspension for gear components, aerial ropeways, gases, metals, coals, etc. for their safe use in mines and other hazardous areas.

Application of Boundary Element Finite Element (BEFE) Software

CMRI has acquired versatile BEFE software for two and three-dimensional stress analysis of underground rock excavations for their design and stability. The package from Computer Systems and Services International, Austria is valuable for Civil and Mining Sectors for designing of various excavations, both large and small. BEFE employs boundary element, finite element or couped mesh and because of this facility is flexible and fast on the computer. There are only two such packages in India, one of them being in CMRI.

Human Resource Development

Training Programmes/Workshops

NML organised for the industry diverse training programmes for:

- Component Integrity Evaluation (CIE);
- Experimental Techniques in Industrial Metallography;
- Modern Methods of Chemical Analysis for Minerals, Metal, Refractory Materials and Ferro alloys.

Recognitions and Awards

CSIR Young Scientist Award for Engineering Sciences	• Dr. M. Verman, CMRI • Dr. S. Srikanth, NML
CSIR Technology Prize for Engineering Technology	• Prof. B.B. Dhar & Sri Sivnath Maity, CMRI
NRDC award for meritorious invention	• Dr. T.N. Singh & Sri B.K. Dubay, CMRI
Diwan Bahadur DD Thacker Gold Medal	• Prof. B.B. Dhar, CMRI
Indian Ceramic Society Award for Refractory Technologists (1995)	• Dr. G. Banerjee, CGCRI
Metallurgists Award	• Dr. B.C. Pai, RRL-Tvm.



S&T FOR SOCIETAL DEVELOPMENT

Poverty and unemployment continue to be major societal concerns in India for which there are no easy solutions or short cuts. Undoubtedly inputs of science and technology could help to optimise the returns from the modest outlays and investments devoted to the sector. Several CSIR laboratories have S&T programmes that address the diverse needs of societal development, ranging from devising useful designs, techniques, processes and technologies for decentralised employment generation, using local specific endowments, such as energy saving devices, potable water, sanitation and housing. Emphasis of CSIR's activities was on dissemination of technologies developed as well as on new programmes to address real life problems, the overall contributions of the CSIR were for:

Low-cost housing

Building components Production units	18 no.

Medicinal and aromatic plants

Land brought under cultivation (additional)	1020 ha
Planting material provided	2310 parties

Hops Plantation

Land brought under plantation (additional)	120 ha



Training of Artisans for Building Components Casting



Leather

Training in production of wet blue chrome leather to artisans (mostly SC/ST)	500 no.

Energy efficient devices

Chulhas adopted through state govt. departments	3.2 lakh

Farm implements

Power paddy thresherwinnowers adopted	1000 no.
Multipurpose power grain winnower adopted	200 no.

Science

A Computer Aided Design (CAD) package has been developed by NISTADS in collaboration with IIT, Kharagpur for designing of traditional Bengal Sarees (Balucheri). The development was sponsored by the Development Commissioner for handloom. The CAD was demonstrated to the traditional designers and weavers in Bishnupur and Varanasi through the local weavers societies. The demonstrations have established the feasibility and demand for CAD facilities and its acceptability by the traditional designers in the handloom sector.

Technology for Intellectually Impaired Women

NISTADS was sponsored by the Indian Council of Social Science Research to conduct a survey of technologies that may be appropriate for intellectually impaired women and the DST supported an in-depth study of the identified technologies. The study has led to the formulation of non-conventional economically viable vocational schemes for the habilitation of intellectually impaired women. One such demonstration scheme of technology of Mushroom (Oyster) cultivation has already been introduced in Aanchal, NDMC, New Delhi school for the mentally handicapped. The programme has established the economic viability and habitational potential of this non-conventional vocation.



Technology

Chemical Hydrofracturing of Clogged Tube-wells

Encrustation is common cause for tube-wells to yield reduced water output and in a sea extreme cases, complete failure. The encrustation due to deposition of organic or inorganic materials within the gravel shroud around screen, the surfaces of the screen, the casing or the pump, discharge assembly. RRL-Bho. took up a project to rejuvenate clogged tube-wells by using chemical hydrofracturing. Water samples from the tube-wells in villages near Bhopal, identified in collaboration with PHED Engineers were collected. The residual solid material after complete evaporation of water was studied

and prepared for lossening of the cloggy encrustation. On use of the non-toxic chemical cleaning process substantial increase in water was noticed.

Extension Programmes

CSIR laboratories arranged 128 extension courses and participated in 24 exhibitions during the year. A major event was CSIR's participation in the National Exhibition on Rural Housing "`GRAMAVAS', at Pragati Maidan, New Delhi during November 1995 to Feb.1996 in which six CSIR laboratories participated and demonstrated technologies on wood substitutes, ferrocement building components, rain water harvesting, etc.

Compendium of CSIR Rural Technologies

To disseminate CSIR developed technologies suitable for rural areas and to promote greater interaction with ministries and the concerned government departments, a compendium, both in English and Hindi, on CSIR rural technologies was brought out containing salient information on about 350 technologies.

Vitamin A Fortification by Palm Oil

At the completion by RRL-Tvm., of the first phase of the National Programme for Eradication of Vitamin-A deficiency in pre-school children from the disadvantaged section of the society, it was seen that a significant improvement in the level of Vitamin-A was effected by the intake of red palm oil. The study under the programme was conducted on about 2000 children from the age group of 3-5 years, selected from 80 locations in Tamil Nadu, who were fed with red palm oil in their noon meals for two years.

Working Manual On Low Volume Roads

CRRI prepared a working manual on construction and maintenance of low volume roads which provides information on technologies and maintenance management practices of low volume roads. This document will be useful in rural road development programmes.



Techno-Economic Survey of Unorganised Pottery Sector

A techno-economic study was carried out on the status of the pottery and ceramic goods segment of the unorganised sector of industry sponsored by the National Bank for Agriculture and Rural Development (NABARD), Bombay. Analysis of data gathered from 24 States and Union Territories of India revealed that:

a) around 15 lakh potters with traditional skills are engaged in the unorganised pottery sector of pottery;

b) 95 percent of potters are engaged in the traditional red/local clay pottery;

c) 95 percent of them get the needed raw material within 5 km of their location white clay is available at a distance between 50 and 100 km;

d) production is limited to age old traditional items and those clusters which are near to cities are producing sophisticated pottery items.

Human Resource Development

Technical Training for Rural Youth

Cashing on its location in a remote area surrounded by an agglomeration of backward rural settlements, CECRI took us in a big way to the task of societal development in the vicinity of Karaikudi through Human Resource Development. Training was imparted under two schemes: (i) Mass Employment Generation through Science and Technology (MEGSAT); and (ii) Science and Technology Entrepreneurship Development (STED). The MEGSAT scheme trains educated rural youths in practical aspects of various trades like domestic wiring, plumbing, fitting, welding etc., repair and servicing of consumer electronic goods, mushroom and spawn production and air-conditioning and refrigeration. Under the STED Scheme training was imparted in leather goods making, screen printing, food processing. Nearly 300 rural youth were trained in various trades and for skills useful in diverse industries.

Dissemination of Knowledge for Medicinal and Aromatic Plants

Seven training programmes-cum-demonstration and skill-cum-technology upgradation programmes sponsored by Small Industries Development Bank of India (SIDBI), Lucknow, were organised by CIMAP at different medicinal and aromatic plant growing areas with the objectives to provide training and retraining farmers, representatives from industry, NGOs and Government departments including funding agencies in cultivation, processing and marketing aspects of medicinal and aromatic plant products.



Four "grower-industry-scientist meets" at different parts of the country sponsored by the Spices Board, Cochin and UPSHCMF, Lucknow, were organised by CIMAP. These meets were aimed at popularising improved agro and processing technologies and improved plant varieties of various mint species. CIMAP also organised an awareness camp on the cultivation and processing aspects of medicinal and aromatic plants in Gorakhpur district of Uttar Pradesh. This camp benefited about 500 farmers.

Recognitions & Awards

Chandaben Mohanbhai Patel Industrial Research Award for Women Scientists (1992)	• Dr. Mohini Srivastava, RRL-Bho.

■ CENTRAL MANAGEMENT ACTIVITIES

CSIR is a multi locational, multidisciplinary organisation comprising 40 laboratories, 80 field stations manned by around 23,000 people with around 2500 people in a floating mode. The management of such a large, decentralised and dispersed organisation is a challenging job. CSIR has been adopting to the changing national economic, trade and IPR regimes through appropriate organisational and management responses evolved from time to time by the HQs. The CSIR HQs. has been the custodian of protocols, procedures and guidelines for marketing different components of knowledgebase, international collaboration, resource allocation, financial accounting and career advancement. It has been marketing the brand equity and catalysing and co-ordinating large inter-laboratory, inter-agency mission mode programmes by synergising core competencies, liaison and interacting with government agencies, financial institutions industry associations and other major customers.

The affairs and activities of CSIR are managed by the Director General, CSIR under the guidance and directions of overarching bodies namely the CSIR Society, Governing Body, and advise and assistance of Advisory Board and the five Technical Advisory Boards. Brief details of the activities of these bodies are given hereunder.



The meeting of the Society was held on 30th August 1995 with the Hon'ble Prime Minister Shri P.V. Narasimha Rao in the chair and among others with the Finance Minister Dr. Manmohan Singh and the Industry Minister Shri K.

Karunakaran as participants. The Society considered the outline of the white paper 'Realising Our Potential: Towards a New CSIR' and endorsed it. The Society encouraged CSIR to take the lead in creating patent awareness and literacy not only in the CSIR but the country. The Society urged CSIR to examine the possibilities of down sizing some of the technologies and processes for their appropriate usage. Another item that Society desired CSIR to look into was that of cost-effective housing designs and materials. The membership of the Society is given at Annexure-III.

Governing Body (GB)

Four meetings of the Governing Body were held during the year. The volume and value of the items considered were significant, and the GB gave directions on several crucial issues interalia on:

- Realising our Potential: Towards a New CSIR;
- New mechanisms for marketing of CSIR knowledgebase;
- Medical facilities for retired CSIR employees residing outside Delhi;
- Revised pay scales for Assistants and Senior Stenographers;
- Absorption of casual workers; and
- Construction of Golden Jubilee Block at Hqrs. and Silver Jubilee Block and Animal House at ITRC.

The membership of the GB is given at Annexure-IV.

Advisory Board (AB)

Two meetings of the AB were held in the year.

The 12th meeting of the AB was held on 22nd August, 1995 at New Delhi. The AB considered the need for CSIR to attract quality human resources from academia and industry and suggested that this was an opportune time to reorient CSIR to realise the expectations of the industry and other stakeholders. The Board desired a review of the personnel policies for induction of young people, promotional avenues, services and salary structures and of the project portfolio with a view to shed infructuous projects. It considered the CSIR approach to 'Realising Our Potential : The New CSIR'. It suggested interalia that CSIR's mission be 'To help maximise the social, economic and environmental benefits from scientific-industrial research for the people of India'. Based on the inputs of AB the white paper was revised.



The 13th meeting of the Advisory Board held on 8th September, 1995 at NAL, Bangalore was an Interactive Brainstorming Meet with the Directors of CSIR laboratories. The Board emphasised the need to redefine targets and the exclusive products which could be placed in the marketplace by the year 2001. The membership of the AB is given at Annexure-V.

■ HEADQUARTERS ACTIVITIES

R&D Planning & Business Development Division

The Division was formed with a view to integrate the business development and marketing functions with the process of R&D planning, prioritisation and allocation of resources. As a result the two functions viz.: planning, and business development functions hitherto being performed in the erstwhile Planning and Technology Utilisation Divisions were integrated in the new R&D Planning and Business Development Division.

The Division prepares the Annual and Five Year Plans of CSIR, co-ordinates with Planning Commission and the Departmental Parliamentary Committee with respect to the demand of grants and plan allocations for CSIR, and in turn allocates plan resources to laboratories. It promotes business development and marketing of CSIR knowledgebase through interaction with financial institutions, user agencies, government departments, industry associations, technology brokers/licensors. It promotes a culture of 'safety' and GLP work in and fosters formulation of strategic and business planning in laboratories. The Division maintains information on CSIR's R&D outputs and its utilisation.



Working Group for the Formulation of the Ninth Five Year Plan

The Planning Commission in November, 1995 constituted a Working Group to formulate the Ninth Five Year Plan for Department of Scientific and Industrial Research and CSIR with a broad based and balanced membership of 25. The Division provided the secretarial and co-ordinating assistance to the Working Group. The Working Group in turn constituted sectoral sub-groups for thirteen

socio-economic sectors of concern and relevance to CSIR's activities, besides two special sub-groups on Managing Human Resources and Exports to work out in detail the perspective plans. The sub-groups were chaired by experienced and eminent experts in the field and had around fifteen members each representing diverse stakeholders. All the fifteen sub-groups were serviced by the staff members of the Division. The Division finally prepared the sectoral plans based on the inputs of the sub-groups and the Plans of the relevant socio-economic sectors. The Division also represented CSIR on the Working Groups for the formulation of Ninth Five Year Plan for other S&T departments such as Agricultural Research, Atomic Energy, Biotechnology, Science and Technology, Small Scale Industries etc.

Annual Plan 1996-97

The Annual Plan for the year 1996-97 was prepared by the Division, a thrust was given to make the system more user responsive and user driven by preparing sectoral business perspectives to facilitate the laboratories deriving a significant part of their plans from these. CSIR laboratories were in great need for immediate upgradation/replacement of their antiquated equipment and to ushering in modern communication facilities and networking system; consequently, the requirements for modernisation were separately projected in the Plan. The Parliamentary Standing Committee for the Department recognised and recommended a grant of Rs. 50 crore for the year 1996-97 for modernisation of equipment in CSIR.

Business Plans for Laboratories

In view of the changing economic trade and IPR regime it had become imperative for laboratories to look at external economic industrials and trade scenarios in preparing their plans – business plans. To initiate the learning process of preparing business plans for the laboratories help of external consultants was enlisted for assisting in preparing business plans for two laboratories IIP and NEERI. The experience derived has since been used to help IICT & CGCRI in preparing their business plans.

Business Development and Marketing of Knowledge



During the year a total of 190 licence agreement were executed for CSIR's Intellectual Property, contracts worth Rs. 310 crore for R&D and consultancy were in hand. Export of services and technology yielded over Rs. 5 crore.

International Marketing of Knowledgebase

The laboratories consult and seek the advise of the Division in negotiating international contracts. Some important contracts that were dealt with were: Du Pont, USA and NCL for joint 'R&D projects in the area of polymers & catalysts; Du Pont and IICT, Hyderabad for 'discovery and development of agricultural chemicals'; Zelleco Engineering Sdb. Bhd., Malaysia and SERC, Madras for 'Testing of 500kv HVDC towers; System Contractors and

Engineering P. Ltd., Colombo and SERC, Madras for 'design and drawings of plate elements of roof/floor for brick funicular shell house; Carpco Inc., USA and RRL, Bhopal for joint 'R&D projects, and environmental studies in areas of mineral beneficiation and coal preparation; GE Plastics and NCL for a long term collaborative research agreement in the area of polymers; and Seleco International Ltd., Brazil and Hypercoat Enterprises (P) Ltd., Singapore as a Technology Transfer Agents for NAL.

Polytechnology Transfer Centres(PTCs)

Located in the capitals of seven states viz. Ahmedabad, Bangalore, Bhopal, Calcutta, Hyderabad, Lucknow, Patna, PTCs are the CSIR's windows in their respective states. They help the industry and industrialisation effort in the state through diagnostic inputs and arranging for provision of indigenous S&T. They are administered by the RPBD Division. During the year the PTC scientists visited about 680 SSI units to help diagnose technological problems, assisted 740 units and attended to about 2850 technical enquiries; they organised 40 technology awareness/entrepreneur development programmes in collaboration with the agencies in the state and helped to transfer 35 CSIR technologies.

CSIR Technology Awards – 1995

Thirty three nominations for 1995 CSIR Technology Awards were received by the Division and processed through Technology Awards Selection Committee. The awardees of Technology Prizes were: (a) Prize for Chemical Technology: IICT, Hyderabad for the process and engineering design innovation to Glyoxal technology; (b) Prize for Engineering Technology: CMRI, Dhanbad for high set remote prop for underground coal mine working; and (c) Prize for Business Development and Technology Marketing: NCL, Pune for significantly enhancing the business and markets for its knowledgebase. The Shield for Engineering technology was awarded to NAL, Bangalore for diverse technological achievements in engineering.

Directors Conference

With a view to realise the true potential of CSIR, the vision, the strategy, the road map to realise the goals set for CSIR were once again discussed at a Conference of CSIR Directors organised by the Division on 5-6th October, 1995 at CSIR Science Centre, New Delhi. VP,CSIR inaugurated the Conference. The issues discussed were: (a) Indicators for evaluating the performance of laboratories; (b) CSIR Intellectual Property (IP) Policy; (c) New approaches to International S&T opportunities; (d) Strategy for evolving the Ninth five year plan; (e) Mobilising and management of financial resources; (f) Re-engineering and management of human capital; (g) Communications: Intralab-interlab. Lab-CSIR and with external stakeholders (h) Leveraging alliances internal and external. The Conference endorsed the goals set for CSIR and concluded that working together as CSIR Incorporated was the only way that the vision could be realised.



New Idea Fund Scheme (NIF)

In a conceptual breakthrough, the Division introduced a biannual scheme of New Idea Fund to support in-house ideas of explosive creativity and novelty. The aim is to provide funds for proving the feasibility of bold concepts in the first place. The proposals in the prescribed format were invited twice in the year and an expert Committee of eminent scientists/technologists selected the proposals for the award. Two projects one from CLRI, Madras and the other from NAL, Bangalore had been funded under the NIF.

Interministerial Linkages

The Division represented CSIR on various committees of the Government i.e. for recognition and registration of in-house R&D units, Scientific Organisations, and support for Programmes Aimed at Technological Self Reliance (PATSER).

Workshops for Modernisation of Technology of SSIs

Three workshops were jointly organised with NSIC & APCTT in May 95, July 95 and March 96 at Panaji, Cochin and Jullandhar respectively to focus on modernisation and technology upgradation of SSI units in and around these three places. They were the continuation of the series started in the year 1994-95 and brought the total number of Workshops held at different locations to 11.

Enhancing Manpower Capabilities for Business Development

The Division organised a 2-day Business Meet-cum-Workshop at CFTRI, Mysore with the theme 'Making a Business Plan'. Representative of nearly all CSIR laboratories participated in the event.

Creating Awareness

With a view to familiarising scientists and other senior staff with the practices and strategies of R&D management, the Division organised a Workshop on Project Management. To bring in better work culture for CSIR it organised a one-day programme on 'Human Dynamics'.



International S&T Affairs Directorate (ISTAD)

The erstwhile Division for International Scientific Collaboration was re-engineered as the International S&T Affairs Directorate considering the expanded and pivotal role it could play in the realisation of the vision and strategy of CSIR by forging international collaboration and alliances. The Directorate besides operating 40 bilateral collaboration programmes in 35 countries, maintains close linkages with regional, multilateral agencies and awards international fellowships and travel grants. The initiatives of ISTAD were thus for:

Bilateral Co-operation:

(a) New MoUs signed with:

- South Bank University, London
- Biotechnological & Biological Sciences Research Council, U.K.

(b) MoUs under negotiation with:

- CSIR, South Africa
- CSIR, Ghana

(c) On-going Programmes

- CSIR-FHG

Prof. Haus Jurgen Warnecke, President of Fraunhofer Gesellschaft (FHG) was invited to visit India/CSIR. High level discussions with DG, CSIR and senior officers resulted in identifying collaboration in areas of environment, materials, electronics and information science.

- CSIR-NCST, Peru

Areas identified under the Working Programme for Scientific and Technological Co-operation with National Council for Science and Technology of Peru were Mini Cement Plant Technology, Solar Photo-voltaics and Food Processing.

- CSIR-CST, Tanzania

A Protocol for Scientific and Technical Co-operation with Tanzania Commission for Science and Technology, Tanzania was signed in October 1995. The Protocol provides for establishment of the Joint Committee to prepare programmes of co-operation to decide upon the financial, administrative and technical procedures for the implementation of the general protocol.

- CSIR-Czech & Slovak Academies

Protocols on Scientific co-operation with the Academy of Sciences of the Czech Republic and the Slovak Academy of Sciences was signed in June 1995.

- CSIR-KISR, Kuwait

A Protocol on S&T co-operation between CSIR and Kuwait Institute for Scientific Research was signed on 1st June 1995. The visiting Kuwaitian delegation identified Petroleum, Building Materials, Renewable Energy as some of the areas of interest.

- CSIR, BCSIR, Bangladesh

Under the CSIR-BCSIR, Bangladesh agreement on S&T co-operation, six scientists from Bangladesh visited various CSIR laboratories in March 1996 for training/study.



- CSIR-AIST, Japan

As a follow-up of the CSIR-AIST, Japan Agreement on S&T co-operation, a CSIR team visited Japan during May 1995 and identified the areas of possible joint co-operation.

Regional Cooperation

- Commonwealth Science Council (CSC)

The CSC meeting was held at Bangalore in June 1995 with DG,CSIR as its Charman, wherein over 30 participants from CSC countries and donor agencies participated.

- Association for Science Cooperation in Asia (ASCA)

An ASCA Workshop on Cooperation & Capacity Building in Environmental Biotechnology & Strengthening of Biotechnology Institution through Human Resources Development & Institutional Linkages in Asia Pacific Region was organised at the NEERI, Nagpur, in January 1996 with participants from Bangladesh, Singapore, Malaysia, Australia & India.

- UNESCO

The Indian National Commission (INC) for Cooperation of UNESCO met in New Delhi to consider the reports of the five Sub-Commissions on the Draft Pragramme & Budget (1996-97) and the Draft Medium Term Strategy (1996-2001). DG,CSIR, as chairman of the Natural Sciences Sub-Commission presented its report to the INC.

Technical Assistance Programme

ISTAD has catalysed valuable inputs and assistance under the Technical Assistance programme of UNDP, US-India Fund, Indo-EEC and Indo-French programmes.

- UNDP

An overall umbrella programme involving three components, the erstwhile TOKTEN, UNISTAR and TCDC with UNDP contribution of $ 1 million was taken up with CSIR as a nodal agency in January 1996.



- US India Fund

Three projects out of an initial lot of 33 projects from different laboratories (two at NPL, New Delhi and one at CFTRI, Mysore) involving grants of Rs. 93 lakhs were approved for funding from US India-Fund.

- IFCPAR

The Indo-French Centre for Promotion of Advanced Research, New Delhi promotes S&T co-operation between Indian and French Scientists. Six projects with an envisaged project cost of Rs.110 lakh were approved for funding.

- ACIAR

A project valued at $1,40,000 on Phosphine Resistance in Insect pests of stored grain submitted by CFTRI was approved for funding by Australian Centre for International Agricultural Research (ACIAR).

Human Resource Development

ISTAD co-ordinates various activities contributing to international human resource development. These pertain to training/retraining scientists from CSIR and abroad, fellowships for higher studies and grant of partial travel grant to CSIR and non-CSIR Scientists to participate in International Conferences etc.

During the year ISTAD facilitated foreign deputation of over 600 CSIR Scientists, of these around 260 were deputed for participation in conferences/seminars, 72 for training, 67 on leave and the rest as experts under UNDP and other programmes. Partial travel assistance was granted to nearly 210 non-CSIR scientists for participation in international conferences of relevance to CSIR. Five CSIR Scientists (from NIO, IIP, NPL, CSMCRI and RRL,Bhu) were awarded the Raman Research Fellowship of CSIR for period of 3 to 9 months for working abroad in the priority/thrust areas of CSIR. Three Nigerian Scientists were trained for one month each in the CSIR Institutes (2 at Central Drug Research Institute and one at Central Institute of Medicinal and Aromatic Plants).

Participation in Inter-governmental S&T Programmes

The third Indo-Italy Joint Committee Meeting on Science and Technology was held in Italy during Feb., 1996. CSIR participated as a member of the Indian delegation. Priority areas identified for co-operation during 1996-97 were Materials Science & Technology, Medicine & Health, Biotechnology, Particle Physics, Environment, Electronics & Robotics, Conservation of Monuments, Antarctica Research, Agriculture, Patent & IPR. Also two joint projects with CSIR Labs. – one from CCMB and the other from NCL were included in the joint programme.

Overseas Visitors

CSIR received around 70 foreign delegates from Australia, China, Germany, Ghana, Hungary, Japan, Kuwait, Peru, Poland, Russia, Slovak Republic, South Africa, Tanzania and U.K. for discussions, visits and signing of agreements. Besides study visits of twenty persons from Ethiopia, Uganda, Sri Lanka, Kenya, USA, France, Mongolia, Nigeria, West Indies and Sweden were arranged to CSIR laboratories in the areas of Information Sciences, Medicinal Plants, Flour Milling, Food Technology, Biogeochemistry, Leather Research, Electrochemical Research, Biochemical Technology and Aerospace Engineering.



Revision of Guidelines for Foreign Deputations

The extant guidelines governing foreign deputations were revised by a Committee and made comprehensive with respect to all overseas visits/ deputations of CSIR scientists going abroad and foreign scientists visiting India. The guidelines are to be approved by the GB.

Societal & Technological Missions Division (STMD)

Recognising the potential and responsibility of the CSIR to provide S&T inputs to national, societal and technological mission programmes a focal point for coordinating and catalysing the activities was created in the new Division. The highlights of its activities were:

Leather Technology Mission

As a coordinator for the Mission Steering Committee (MSC) the Division organised two meetings of MSC to devise the working strategies and policies for programme implementation. The Division also evolved effective monitoring systems and ensured the provision of all necessary technical and logistic inputs to the Mission. The S&T achievements under the LTM have been covered under the chapter on Leather, earlier in the report.

Technology Mission on Oil Seeds and Pulses (TMOP)

CSIR is a major participating agency in the National Technology Mission on Oilseeds and Pulses and has been designated as the nodal agency for Mini Mission-II related to Post Harvest and Processing Technologies in which 18 CSIR establishments and 11 non-CSIR institutions are participating. The Division catalysed the release of Rs. 6 crore from the TMOP to CSIR. It processed fifteen proposals for new R&D programmes of which eleven were approved. STMD further submitted five proposals to TMOP for seeking funds to promote appropriate CSIR technologies through demonstration of which the three approved were:

- Three Palm Oil Mills of 2 tonnes FFB/hr capacity,
- Thirteen Modern Oil Expeller of 10 TPD capacity,
- Twelve Daal Mills of 800-1000 kg/day capacity.



Through the efforts of the Division three projects for UNDP funding totalling to Rs. 2 crore were approved for:

- Development of low cost daal analogue to augment the pulses scarcity (at CFTRI),
- Small scale pulse milling (at CFTRI),
- Utilisation of waste land with non-traditional oil seeds plant species (at CSMCRI & RRL, Bhu).

Concerted efforts were made to commercialise the technology for Oil Palm

processing developed at RRL, Tvm. by tying up with NRDC. Three project engineering firms have been identified for undertaking the design engineering of the commercial plants. A detailed proposal for setting up a 10 Tonnes FFB/hr plant was prepared for AP Oil Federation, Hyderabad. Negotiations are continuing.

STMD prepared a base paper, providing inputs for processing technologies and value added products from maize, for formulation of a technology mission on maize by TMOP Directorate. The programme has since been approved and a project valued at around Rs. 50 lakhs has been assigned to CFTRI.

A workshop on "Strategies for Development of tree-borne Oilseeds & Niger in Tribal Areas" was organised at RRL,Bhu and a Seminar "Rice Bran Oil Challenges & Opportunities" arranged by OTAI co-sponsored by the STMD.

Rajiv Gandhi National Drinking Water Mission (RGNDWM)

STMD as the nodal point in CSIR for RGNDWM programmes invited proposals from the laboratories for :

- Control of Fluoride and Arsenic content,
- Improvement in traditional technologies,
- Manpower development.

Six new projects were catalysed for CSIR laboratories amounting to Rs. 90 lakhs for field applications of appropriate technologies.

Technology Proving Plant for Nickel Extraction from Chromite Over Burden

STMD has been catalysing the setting up of a Technology Proving Plant of 50 kg/day nickel output, at an estimated cost of Rs. 8 crore, based on RRL, Bhu. technology. Hindustan Zinc Limited agreed to participates in this venture using low grade chromite overburden. A Draft of MOU between CSIR & Hindustan Zinc Ltd. was prepared and is being processed for execution.

Intellectual Property Management Division (IPMD)



The erstwhile Patent – Unit of CSIR was converted to a full fledged division to emphasise and bring to centre stage the role of intellectual property in CSIR. As a consequence the Division enlarged its coverage of IPR and filed 8 applications for copyright of software. The patent filing in India and abroad recorded an all time high of 260 and 60 respectively (See Annexure I). However, the crowning glory for the Division was the formulation and announcement of an IPR policy for CSIR (See Annexure II for the text), perhaps for the first time in India by any organisation. In conformity with the directives of the Society the Division continued its endeavour to spread the message of IPR by organising several seminars in CSIR laboratories and a major seminar on IPR at Indian Institute of Science, Bangalore in collaboration with WIPO.

The HRD Group at CSIR has been contributing significantly to the development of highly qualified S&T manpower at the national level through grant of Junior & Senior Fellowships (JRFs & SRFs), Research Associateships (RAs), supporting Extramural Research (EMR) providing grant for symposia and travel and award of SS Bhatnagar Prizes and Young Scientist Awards.

Research Fellowships/Associateships

A National Eligibility Test (NET) examination is held twice a year for selection and award of JRFs. Around 49,000 applications were received for the two NET examinations and 27,000 candidates appeared for the examinations, of which around 11,000 were selected.

Award of SRFs and RAs is done through personal interviews by Expert Committees. During the year 42 selection committee meetings were held with the participation of 268 experts. Awards for 427 SRFs out of 2026 applicants and 442 RAs out of 1622 applicants were recommended.

Senior Research Associates (Pool Officers) scheme is meant to support highly qualified S&T personnel through temporary placement. During the year 428 SRAs were supported of which 116 were new.

The number of JRFs /SRFs/RAs supported and renewed during the last two years is given below:

Year	JRF	SRF	RA	SRA
1994-95	1300	2500	1200	453
1995-96	2063	2601	1470	428

Extramural Research Schemes and Special Support Programmes

CSIR provides research grants to departments in the Universities with the objective of improving the overall scientific and engineering research in the country. During 1995-96, 129 research proposals, out of a total of 424 were recommended for support. In addition, 413 ongoing schemes were renewed for 1996-97. The total financial implication worked out to be about Rs. 6.3 crore.



Forty-nine proposals for S&T collaboration between academia and CSIR laboratories were recommended for 1996-97 and support of Rs. 75 lakh was provided for these schemes.

Financial assistance is provided to superannuated outstanding scientists under the Emeritus Scientists (ES) Scheme to enable them to pursue R&D or write books/monographs. In addition to 101 ES schemes renewed in the year, 42 new ES were approved for support. The total grant sanctioned came to Rs. 1.7 crore.

Twenty Visiting Associateship Scheme were awarded to guest scientists from outside CSIR to enable them to make use of the advanced R&D facilities available in the CSIR set up.

Nearly 430 applications for travel grant were received from young researchers for presenting papers at the International Conferences to be held abroad, of which 210 were recommended. Also 377 proposals from scientific societies/ institutes/departments for support to organising National/International Conferences/Symposia/Workshops, etc. were received; of these 283 were recommended.

Awards/Prizes

Shanti Swarup Bhatnagar Prizes 1995

The prestigious Shanti Swarup Bhatnagar (SSB) Prizes for science and technology were awarded to ten outstanding researchers.

Young Scientist Awards 1995

Seven scientists received the CSIR Young Scientist (YS) Awards, for in-house excellence in various fields of science and technology.

Unit For Science Dissemination (USD)

The Unit for Science Dissemination at CSIR HQs. played a vital role in obtaining for CSIR a favourable public image through the print and electronic media and by participation in several exhibitions in India and abroad. During the year the division arranged for four major press conferences, issued 10 press releases and participated in 5 exhibitions and expositions as follows:

Press Conferences

- With DG, CSIR on:
  The New Vision of CSIR,
  Release of the White Paper – CSIR 2001 : Vision & Strategy
- For CMRI on :
  Life Safety Kit for Two Wheeler & Eco-freindly garbage loader,
  First World Mining Environment Congress.



Exhibitions/Expositions

- In India
  TECHMART organised by NSIC in New Delhi,
  INDIA INTECHMART organised by FICCI in New Delhi.
- Abroad
  India Trade & Technology Exhibition, Lusaka, Zambia,
  World Tech '95 World Technology Fair, Korhat, Thailand,
  International Spring Fair, Dubai.

RESEARCH PERFORMANCE DATA - 1995-96

PAPERS Laboratory	PATENTS	FILED In India	FILED Abroad	PATENTS SEALED In India	PATENTS SEALED Abroad
CBRI	34	2	-	-	-
CBT	18	2	-	1	-
CCMB	72	1	2	-	-
CDRI	138	16	-	2	-
CECRI	140	11	1	12	-
CEERI	70	-	-	3	-
CFRI	14	2	-	2	-
CFTRI	85	13	1	1	-
CGCRI	69	9	-	3	-
CIMAP	101	5	-	-	-
CLRI	71	4	5	1	-
CMERI	18	3	-	1	-
CMRI	106	11	2	5	-
CRRI	116	-	-	3	-
CSIO	7	-	-	1	-
CSIR (SCHEME)	N.A.	3	-	-	-
CSMCRI	31	1	-	5	-
IHBT	17	-	-	-	-
IICB	84	6	3	1	-
IICT	153	37	2	4	-
IIP	24	6	1	-	-
IMT	36	3	3	-	-
INSDOC	13	-	-	-	-
ITRC	64	2	-	-	-
NAL	70	1	2	-	-
NBRI	89	-	-	-	-
NCL	255	51	24	19	11
NEERI	31	1	-	1	-
NGRI	114	-	-	-	-
NIO	70	1	-	2	-
NISCOM	N.A.	-	-	-	-
NISTADS	43	-	-	-	-
NML	110	7	-	8	-
NPL	162	10	2	2	1
RRL-Bho.	26	10	-	1	-
RRL-Bhu.	101	3	-	6	-
RRL-Jm.	50	8	2	-	2
RRL-Jt.	64	20	7	6	-
RRL-Tvm.	104	11	1	2	-
SERC-G	23	-	-	-	-
SERC-M	66	-	-	-	-
TOTAL	**2859**	**260**	**58**	**93**	**14**



■ CSIR 2001
VISION & STRATEGY

1. THE MOTIVATION

In the last five years, there has been a sea-change in the economic, political and technological environment the world over. Age-old attitudes and mindsets are being discarded everywhere. India has been no exception; its economy has been unshackled and the forces of competition have been unleashed. A new vision of India as a major player in the global setting has been articulated. The wave of change sweeping the country and the world has thrown up myriad of opportunities and at the same time posed daunting challenges for all sections of Indian society.

For India, more than ever before, it is essential to bring together the world of science and the realm of technology in the socio-economic sphere. CSIR has the potential, the ability and the will to initiate and be in the forefront of such an exciting endeavour, as it has great strengths in its manpower and infrastructure and it covers a wide spectrum of R&D knowledgespace. The purpose of this 'White Paper' is to draw up an explicit agenda for realising these aspirations of CSIR and to chart out a distinct and detailed road map of attaining the true potential of CSIR, visualised not in relation to what it used to do in the past but in relation to what others, the world over, are likely to do in the future.

2. MISSION STATEMENT

The interactive coupling between technology, economy, environment, society and politics has never been more intimate and intertwined than it is today. Mastery and management of technology is a fundamental determinant of the wealth creating capacity of a nation and also of its political position and prestige in the comity of nations. Technology has an immense capacity to improve the public services and the quality of life of the people. Thus scientific research and development activities in CSIR have to be directed towards technological development and application that maximise the overall benefits for India. CSIR's Mission statement thus is :

> ***To provide scientific industrial research and development that maximises the economic, environmental and societal benefit for the people of India.***



Industry has a wider connotation than mere manufacturing. Industry encompasses any human activity that transforms the inputs to outputs of value to society. Thus industry would encompass even agriculture, leave alone services. The underlying emphasis is that R&D to be pursued by CSIR

provides traceable and tangible benefits to the economic, environmental or societal welfare systems.

3. TECHNOLOGY FOCUS

Recognising that technological advancement holds the key to India's economic and social renaissance the focus of technology development efforts in CSIR would be on those activities that yield appropriate advantage for the nation. This would be sought to be achieved by directing its R&D activities that lead to technology development for economic growth and for human welfare.

☐ Technology for Economic Growth

It is now recognised that better diffusion of technological knowledge and closer partnership between research community, industry, financial institutions and government are needed to improve India's competitive position. Indeed , CSIR needs to partner Indian industry to support its effort to compete successfully in the global setting and prepare for and adapt to the unprecedented global changes. It is essential that the interaction and relation between CSIR and industry be a symbiotic partnership, where the core competencies of both will reinforce each other.

India is blessed with vast natural resources, rich biodiversity and abundant manpower which need to be gainfully utilised. Exploitation of these endowments requires technological intervention. Thus CSIR's endeavour for promoting economic growth would be twofold to:

- **partner Indian industry enabling it to emerge as a significant global player; and**
- **assist the nation in deriving enhanced and sustainable value from endogenous resources.**

☐ Technology for Human Welfare

Recognising that scientific and technological inputs could significantly contribute to improve the quality of life and public services, CSIR would endeavour to:

provide S&T based solutions to mitigate the vulnerability and improve the quality of life, especially, for the weaker and disadvantaged sections of the society.



4. CSIR VISION: 2001

CSIR, with its complement of 10,000 highly qualified scientific and technical personnel, is amongst the largest R&D organisations in the world for scientific and industrial research. Over the years CSIR has contributed to many vital scientific, industrial, strategic and human resource development endeavours. In recent times it has responded to the changing national and international

economic, trade and IPR regimes through appropriate organisational and management adjustments. As a result, around 30% of CSIR's turnover is derived from contract R&D and services, it files and owns more number of Indian patents than any other organisation and its initial forays in the international knowledge marketspace have met with a remarkable success, with some of world's leading multinationals seeking strategic alliances with CSIR. This has now emboldened CSIR to set for itself higher sights and goals tempered with the sanguine realisation of the increased international competition, plummeting technology development times and its own desire to become substanitally self-financing. The belief that the prevailing environment in the country and within the CSIR is conducive, more than ever before, to engineering the transformation of CSIR, has influenced the enunciation of an ambitious vision of what CSIR can be in the year 2001.

☐ **CSIR in 2001 would be:**

- **a model organisation for scientific industrial research and a path-setter in the shifting paradigm of self-financing R&D;**
- **a global R&D platform providing competitive R&D and high quality science based technical services world over; and**
- **a vital source of S&T for national societal missions which combine technology with a human face.**

This is a grand, yet by no means an unrealistic dream. Realising it would need setting quantifiable tasks and targets along the path in time against which CSIR could be benchmarked and judged.

☐ **Goals set for the year 2001 are to:**

- **move towards the path of self financing by generating over Rs.7 billion from external sources, as against Rs.1.35 billion in 1994-95, of which atleast 50% will be from industrial customers (up from 15% in 1994-95);**
- **develop at least ten exclusive and globally competitive technologies in niche areas;**
- **hold a patent bank of 500 foreign patents (up from < 50);**
- **realize 10% of operational expenditure from intellectual property licensing (up from < 1%); and**
- **derive annual earnings of $ 40 million from overseas R&D work and services (up from < $ 2 million).**



Admittedly, these goals are not a mere extrapolation of our past accomplishments but a quantum jump in our ambition. In the past CSIR had always lived up to the expectations and aspirations of the nation and now given a clear vision and a motivated workforce – these tasks and targets, though formidable, should be within the realm of realisation.

5. STRATEGIC ROAD MAP

The strategic road map aims at charting out the directional path and contours of the organisational structures and processes required to realise the vision and achieve the goals set for the year 2001. The road map has been derived after thoughtful consultations and shared common understanding of the extant practices, procedures, processes, structures-formal and informal, and the instruments needed to realise the true potential of CSIR. The road map accordingly dilates on five main aspects of the reform process, namely :

- **re-engineering the organisational structure;**
- **linking research to marketspace;**
- **mobilising and optimising the resources base;**
- **creating an enabling infrastructure ; and**
- **investing in high quality science that will be the harbinger of future technologies.**

These aspects are dealt with individually, in detail in the following paragraphs.

6. RE-ENGINEERING THE ORGANISATIONAL STRUCTURE

Structures determine and decide organisational efficiency, productivity, functionability and also originality. Restructuring is one word that encapsulates the accomplishments and limitations of the past, captures the excitement and concerns of the present and symbolises the promise and vision of the future. The increased external competition and specialisation demands that a globally competitive organisation has a structure that is flexible and capable of responding to situations, opportunities and challenges quickly and effectively. This would necessitate that an optimal balance is struck between decentralisation and devolution of autonomy to the working level and foresight clubbed with strategic planning residing at higher levels of organisational echelons.



CSIR's present organisational structure tends to promote hierarchies, retard individual initiatives and enterprise and empowerment of scientists and lacks instruments for promoting inter- and intra-laboratory coordination . As a result, market responsiveness has not been to the desired level. For CSIR to compete in the global knowledge marketplace, it needs to restructure itself along virtual corporate lines and processes. CSIR's structure for tomorrow cannot spring anew from the drawing board, the antiquated legacies of the past have to be undone. Thus, within the limitations of a publicly funded R&D system, CSIR would evolve an organisational structure of a **virtual corporate entity**. The first step in this endeavour would be to seek and realise the functional and operational autonomy in financial and personnel management enjoined by the society structure of CSIR, if need be through an MoU arrangement with the government.

The Headquarters would be restructured to help catalyse and facilitate the laboratories to move towards self financing and to perform the central corporate functions of policy formulation, foresight, strategic planning and monitoring, budgetary resource allocations, interfacing with government, communicating with stakeholders and the lay public, besides functions enjoined by CSIR bye-laws such as audit, vigilance and parliamentary affairs.

The Advisory Board (AB) and Technology Advisory Boards (TABs) were introduced as new organs in the CSIR structure on the recommendations of SAC-PM with a view that CSIR have the best of expert advice for programme identification, prioritisation and management. Over the years, these advisory constituents have been bestowed with functional responsibilities for programme formulation and resource allocations, career advancement etc. In keeping with the original spirit and intentions of SAC-PM and the high level membership of AB and TABs , these would be more effectively made use of in evolving and influencing CSIR S&T policies and in chartering future directions for CSIR.

At the laboratory level, each laboratory would be considered as a subsidiary corporate entity. The Director would be the CEO of the laboratory and in place of the Management Council (MC) would have an Executive Board to assist him in the management of the affairs of the laboratory. Performance related accountability, incentives and rewards would be introduced and the laboratories would be accorded autonomy in operations related to and dependent on the extent of their committed output and deliverables – the higher the growth rate committed and achieved the higher will be the level of independence from HQs. and the laboratory rewarded suitably.

The Research Councils (RCs) have been assigned functional responsibility but without any operational powers and accountability. In order to derive the best advantage of the high quality expertise of the RC membership, it will now help the laboratory in deriving its vision and direction and as a S&T sounding board for the ideas and programmes of the laboratories.

7. REORIENTING PROGRAMMES & ACTIVITIES

Trade and tariff barriers amongst nations are disappearing with the result that the innovation chain from concept to commercialisation is crossing national boundaries. There would be no captive or protected markets for R&D and services that CSIR could rely on and competition would become fiercer every year. CSIR, thus has no alternative but to view R&D as a business, a transformation process which adds value to inputs, efficiently and profitably. Each laboratory would thus be encouraged to evolve five year business plan, and not just R&D plans, with external professional inputs and assistance.



CSIR and the laboratories must accept that they are a small component of a large international knowledge supply system and cannot hope to mobilise requisite intellectual or financial resources to excel and capture business over a wide range of R&D activities. It is now recognised that an organisation

cannot afford or justify assembling in-house all the skills and facilities to carry out competitive R&D and often the pace of change denies them the opportunity to do so. Economic globalisation is compelling even business rivals and competitors to forge alliances and share their resources to develop new products, achieve economies of scale and gain access to new skills and technologies. CSIR and its laboratories have thus to plan, prioritise and pursue their R&D programmes and activities to minimise risks and to optimise the returns on investments. It then becomes imperative to use CSIR's own scarce resources to the best purpose by co-operating in a symbiotic and profitable partnership, not only with other laboratories of the CSIR but also leveraging alliances externally with other constituents of the innovation chain nationally and internationally. CSIR's business strategy would thus seek to link and relate its R&D to market place by:

- **studying and analysing technology and market trends and forecasts to identify niche opportunity areas, partners, customers, competitors and markets;**
- **evolving a balanced portfolio of projects: some that are industrially led, cost shared and market driven whilst others that are self propelled and create new processes, products, applications and markets;**
- **shedding and divesting programmes and activities that are non-viable; and**
- **exploring and establishing synergistic alliances, consortia and networks that minimise costs and risks of R&D and optimise on value addition and returns on outputs.**

All of this would necessitate continuous interfacing of knowledge workers with the market place, an activity that could be best done through effective business development and marketing systems.

8. EFFECTIVE MARKETING SYSTEM

CSIR and the laboratories hitherto had been adept at analysing and understanding complex S&T phenomena and generating science based innovations. The ideas of linking their programmes and activities to the market place and more so of viewing R&D as a business process are rather new to the system. The implementation of the recommendations arising from two recent reports, titled "Creating an Enabling Environment for Commercialisation of CSIR Knowledgebase" and "New Mechanisms for Marketing of CSIR Knowledgebase", have significantly influenced CSIR's thinking and shaped its initiatives to reach out to the market place. The results are already visible; a buoyant business activity and enhancement in external cash flow in CSIR.



Marketing of R&D knowledgebase is different from marketing of physical products and goods or even services. It is best done by persons who are closest to and involved with the generation of the knowledgebase as they

are emotionally attached and well versed with diverse nuances and variations of it. Thus **the entrepreneur in a scientist** would be awakened, equipped and motivated to venture out in the knowledge marketspace. The strategy to further enhance the marketing of CSIR knowledgebase would be to:

- **develop, through appropriate training, skills of scientists for diverse aspects of business development and marketing activities;**
- **involve and associate professionally equipped personnel/ group in each laboratory and/or external (foreign/Indian) organisations/ consultants in business development and marketing activities;**
- **permit select CSIR laboratories to set up separate companies/ legal entities for business development and marketing;**
- **create marketing outlets abroad;**
- **twin with R&D institutions and organisations to realise synergy of business opportunities; and**
- **act as technology scout for Indian and foreign organisations to help them to evaluate, select, transfer, upgrade, and add value to R&D and technological inputs.**

All these would require an effective system to provide the requisite legal backing and protection to CSIR's knowledgebase.

9. STIMULATING INTELLECTUAL PROPERTY ORIENTED OUTLOOK

The effectiveness of Intellectual Property Rights (IPR) as a tool for global competitive advantage has gained major impetus and importance since the early eighties. Although CSIR has a strong science base and presently files and owns more number of Indian patents than any other organisation, yet its leveraging and earnings from patents have not been comparable to other industrial R&D organisations elsewhere. The skills and competence to manipulate IPR to gain leveraging influence and competitive advantage is not available in adequate measure either in CSIR or in the country. CSIR has taken early initiatives to mount a major patent literacy mission for its own personnel and to enunciate an IP policy. CSIR's IP policy is:

To maximise the benefits to CSIR from its intellectual capital by stimulating higher levels of innovation through a judicious system of rewards, ensuring timely and effective legal protection for its IP and forging strategic alliances for enhancing the value of its IP.



The IP policy would inter-alia seek to:

- **stimulate and encourage increased creativity and innovation in CSIR to gain economic advantage;**

- **develop skills amongst the scientists to understand, interpret and analyse the techno-legal and business information contained in patents and other IP documents;**
- **use the information acquired from analysis of IP documents to direct and mount strategic R&D programmes;**
- **establish systems of recording and documentation of experimental results and data that would be accepted and respected by patenting authorities the world over;**
- **evolve appropriate systems to capture and assess the intellectual property generated in the CSIR system;**
- **provide the highest level of professional techno-legal services nationally and internationally for securing and protecting the IP generated;**
- **manage the portfolio of IP as a business activity;**
- **manipulate the patent portfolio, defensively and aggressively, to forge strategic alliances/international S&T collaborations, to gain business advantage and ward off competition; and**
- **mobilise and influence national thinking on IP related issues and concerns.**

The endeavour would thus be to:

- **identify and mount applied research projects after thorough analysis and assessment of techno-legal and business information in related IP documents and monitoring global patent position for mid-term project appraisal for which requisite pre-project budget and funds would be allocated;**
- **encourage the publication of R&D results in scientific papers after careful consideration of the consequences on IP rights. A quick and effective system at each laboratory would be established to scrutinise the scientific papers and media releases on achievements/ developments proposed in terms of the IP information contained therein;**
- **monitor national & international patents and other IP developments through access to on-line databases, to ensure effective protection for and to ward off infringements and threats to CSIR's IP portfolio and vice-a-versa; and**
- **analyse and assess techno-legal and business information & market intelligence to identify potential strategic alliances and to exploit uncovered niche areas of opportunities.**



It is envisaged that in 2001 CSIR will, apart from filing 1000 patents per year, hold a valuable portfolio of at least 500 foreign patents, which will enable it to strike strategic alliances with some of the global technological

leaders in specific areas and help generate at least 10% of its R&D budget from IP licensing.

10. HUMAN CAPITAL MANAGEMENT

CSIR's productive assets are its people and the impressive network of R&D infrastructure. CSIR's core competency is brain power of its qualified, experienced and skilled manpower. The scientific human capital base of CSIR is vast and in some cases the scientists rank individually amongst the best in the world. The present stock of scientific manpower at the time of recruitment were then amongst the best available in the market place. Investments in keeping the knowledge, expertise and skills of the CSIR scientists updated and contemporary have been inadequate and this has adversely affected their creativity and realisation of the gains for the system. There is thus an immediate need for re-engineering CSIR's human capital stock to enhance its level of performance. This would be sought to be realised by :

- **putting in place professional Human Resources Management group in each laboratory;**
- **evolving long term human resources plan for each laboratory;**
- **setting up crash programmes to enhance and update the skills base of the staff through appropriate programmes and placements in India and abroad; and**
- **professionalising R&D management and support functions through appropriate training and induction of professionals.**

CSIR today is unable to attract the best of R&D talent in the marketplace, though there is no dearth of scientists/technologists willing to join CSIR, as the supply side is much larger than the demand for R&D personnel. Also unlike academic institutions, where there is a continuous influx of new and young talent in the form of research students and in-house R&D units in industry where the mobility due to attractive fiscal package is high, there has been no significant influx of new talent in most CSIR laboratories for over a decade! The inevitable outcome is that the turnover of scientists from the CSIR system has been small and their average age today unduly high for a creative knowledgebased organisation.



Infusion of new ideas and young talent in CSIR is essential for rejuvenation of its knowledgebase. While inducting sizeable number of young staff in the system, CSIR also will endeavour to be **'virtually young'** by:

- **attracting, through provision of appropriate facilities, bright young talent in a transient or floating mode;**
- **recruiting and nurturing young talent through global search;**
- **promoting cross flow of personnel through inter-change between CSIR and diverse constituents of innovation chain; and**

- **liberalising sabbatical leave and scientist-entrepreneur schemes to encourage CSIR scientists to venture out and refurbish their knowledge and skillsbase.**

Providing attractive remuneration package, reassuring prospects of career advancement and congenial work environment are pre-requisites for optimising the returns out of the present stock of human capital and attracting the best of R&D talents in the market place. CSIR has already initiated schemes to substantially enlarge on the reward and financial remuneration package linked to group performance and output. These efforts would now be further consolidated. Career advancement for S&T personnel in CSIR is now governed by a Merit and Normal Assessment Scheme (MANAS). While MANAS has introduced greater transparency in career advancement, it has some serious lacunae. Accordingly MANAS would be re-examined to enable an effective system of performance linked career advancement to be instituted. For CSIR to secure competitive advantage in the global setting, the various components of its human capital, scientific, technical, managerial, administrative and financial personnel have to work and act in harmony and unison. Thus good work in any and every sphere, and not only scientific, will be recognised and rewarded suitably. A good worker would also be accorded opportunity, preferentially to upgrade his skills and knowledgebase through CSIR support.

11. THE FINANCE CHALLENGE

As a publicly funded organisation CSIR derives its finances from three major sources :

- **Grant-in-aid from the Government**
- **Fee from customers for R&D and technical services**
- **Interest and receipts from non-R&D activities.**

At present the grant-in-aid contributes around 70% of the overall budget and the endeavour would be to decrease the contribution of grant-in-aid to 50% of the budget by the year 2001. This would necessitate significant increases in the non grant-in-aid resources. Indeed, on the basis of present projections, it would mean a five fold increase in non-grant-in-aid resources by the year 2001! This is all the more challenging as most CSIR laboratories are handicapped in competing globally as they have to work with decades old equipment and infrastructure. In order to service the global market, CSIR laboratories would need to seek GLP and ISO accreditation . All this would necessitate raising vast additional resources over the next five years for refurbishing the equipment and facilities in the laboratories. This calls for originality and ingenuity in mobilising and raising financial resources from very constricted money markets for knowledge organisations. In order to advise, guide and assist in this endeavour a strategic group of experts would be set-up with a view to advising and assisting CSIR on:



- **tapping hitherto unexplored funding sources and markets;**
- **devising novel routes and mechanisms for raising financial resources; and**
- **accessing funds from foreign sources.**

Utmost dilligence and care would be exercised in incurring expenditure and making investments. The budget allocations to laboratories would be linked to their performance as determined by a set of agreed output performance parameters with time dependent weightages. Also efforts would be made to get "more out of less" by efficient and optimal use and deployment of existing resources by:

- **encouraging and enabling better and fuller use of R&D equipment and infrastructure;**
- **leasing/hiring of underutilised R&D infrastructure and physical assets;**
- **networking & consolidation of units and laboratories; and**
- **strict financial and physical monitoring of projects and performance of laboratories.**

12. ENABLING INFRASTRUCTURE

To compete globally CSIR has to function at the peak of its efficiency and productivity. This requires its R&D infrastructure and R&D management structures and systems to be benchmarked at international levels for quality and timeliness of response to markets and customers, and a motivated workforce. Financial resources were, and continue to be, the major constraints to modernisation of the infrastructure and systems; with the financial initiatives and strategy already mounted recently these would be mitigated to some extent and vigorous efforts are planned to:

- **modernise and upgrade, selectively and in a phased manner, the existing equipment and facilities;**
- **provide funds to laboratories to access business-led information through commercial data bases and intelligence to enable them in devising their R&D strategy and business plan;**
- **establish a computer communication network within each laboratory and its connectivity across all of CSIR and to international networks;**
- **revamp the management information system through computerisation of accounts, project management & monitoring and personnel management;**
- **improve and enlarge the communication channels with customers and stakeholders;**



- **establish transparent and accessible communication and interactive system between staff and management; and**
- **provide more amenities to staff and their families such as housing to more of staff and research scholars by increased construction of houses and leasing of accommodation and community facilities on campus.**

13. ROLE OF BASIC RESEARCH IN CSIR

Science opens up new insights and approaches for technology development, helps leap-frog rather than follow the trodden path and provides the basis and understanding for know-why of technology. CSIR recognises that there is no high technology without high science. CSIR must discerningly use its limited human and financial resources to support basic research in highly selective areas. CSIR needs to outsource a lot of its basic research from the academic institutions through appropriate instruments and mechanisms. Thus basic research in CSIR would be free but focussed to the objective of providing knowledgebase and skills for generating technology and techniques of the future. CSIR's strategy would thus be to:

- **invest in basic research that supports its "scientific industrial research" programmes;**
- **initiate a 'New Idea Fund' to generate, on a competitive basis, high-risk new research ideas of explosive creativity;**
- **harness the creativity of research fellows and scholars in CSIR for developing science required for new technology development effort;**
- **direct CSIR's extra mural research funding to provide the basic research for scientific industrial research in CSIR;**
- **integrate on a regional basis appropriate academic institutions with CSIR laboratories;**
- **twin with academic R&D institutions for symbiotic R&D programmes; and**
- **establish selective schools of science in CSIR that rank amongst the best in the world.**



14. REALISING THE VISION

We recognise that the bold and daring road map drawn up is only an enabling artefact and the mechanisms and instruments suggested are necessary but not sufficient to reach our destination – the realisation of our full potential. There are no short cuts or guide maps to help us navigate through the untraversed path. The spirit of adventure and self confidence supported by diligence and determination are the only sign posts on our exciting journey. We have a long way to go, but our vision is clear and our resolve firm.

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