VOLUME - I

REPORT OF THE WORKING GROUP ON CSIR

ELEVENTH FIVE YEAR PLAN 2007 - 2012

OCTOBER 2006

CSIR ESTABLISHMENTS

CBRI	Central Building Research Institute, Roorkee -247 667
CCMB	Centre for Cellular and Molecular Biology, Hyderabad-500 007
CDRI	Central Drug Research Institute, Lucknow -226 001, cdriindia.org
CECRI	Central Electrochemical Research Institute, Karaikudi -623 006
CEERI	Central Electronics Engineering Research Institute, Pilani -333 031
CFRI	Central Fuel Research Institute, Dhanbad -828 108
CFTRI	Central Food Technological Research Institute, Mysore-570 020
CGCRI	Central Glass and Ceramic Research Institute, Kolkata -700 032
CIMAP	Central Institute of Medicinal & Aromatic Plants, Lucknow -226 015
CLRI	Central Leather Research Institute, Madras -600 020
CMERI	Central Mechanical Engineering Research Institute, Durgapur -713 209
CMRI	Central Mining Research Institute, Dhanbad -826 001
CRRI	Central Road Research Institute, New Delhi -110 020
CSIO	Central Scientific Instruments Organisation, Chandigarh -160 030,
CSMCRI	Central Salt & Marine Chemicals Research Institute, Bhavnagar -364 002,
IGIB	Institute of Genomics & Integrative Biology, Delhi -110 007
IHBT	Institute of Himalayan Bioresource Technology, Palampur -176 061 (HP),
IICB	Indian Institute of Chemical Biology Jadavpur, Calcutta -700 032
IICT	Indian Institute of Chemical Technology, Hyderabad -500 007
IIP	Indian Institute of Petroleum, Dehradun -248 005
IMT	Institute of Microbial Technology, Chandigarh -160 036
ITRC	Industrial Toxicology Research Centre, Lucknow -226 001
NAL	National Aerospace Laboratories Bangalore -560 017
NBRI	National Botanical Research Institute, Lucknow -226 001
NCL	National Chemical Laboratory, Pune -411 008
NEERI	National Environmental Engineering Resarch Institute, Nagpur -440 020
NGRI	National Geophysical Research Institute, Hyderabad -500 007
NIO	National Institute of Oceanography, Goa -403 004
NISCAIR	National Institute of Science Communication And Information Resources , New Delhi-110012
NISTADS	National Institute of Science Technology and Development Studies, New Delhi-110012
NML	National Metallurgical Laboratory, Jamshedpur-831 007
NPL	National Physical Laboratory, New Delhi -110 012
RRL-BHO	Regional Research Laboratory, Bhopal -462 026
RRL-BHU	Regional Research Laboratory, Bhubaneshwar -751 013
RRL-JAM	Regional Research Laboratory, Jammu Tawi -180 001
RRL-JOR	Regional Research Laboratory, Jorhat -785 006
RRL-TRI	Regional Research Laboratory, Thiruvananthapuram -695 019
SERC	Structural Engineering Research Centre, Chennai -600 113

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CHAPTER - 1

REVIEW OF THE TENTH FIVE YEAR PLAN

1.1 INTRODUCTION

Council of Scientific and Industrial Research has established a network of national laboratories/institutes in various parts of the country to undertake research in diverse fields of science and technology with emphasis on applied research and utilization of results thereof. There are at present 38 research establishments including five regional research laboratories. Some of the establishments have set up experimental, survey field stations to further their research activities and 39 such stations attached to 16 laboratories are functioning at present.

As is their mandate the CSIR laboratories are engaged in research, both basic and application oriented, which contributes to the advancement of Indian science and industry and fulfillment of the societal needs such as food, fuel, buildings, roads, etc. Out of these, a few are concerned with problems of interest to specific industries, like biotechnology, chemicals, drugs & pharmaceuticals, electronics, glass and ceramics, leather, mining minerals and metals, marine chemicals and scientific instruments. There are other laboratories concerned with research in mechanical engineering, aerospace science and engineering, electrochemistry, geophysics, oceanography, experimental medicine and toxicology and metrology. The regional research laboratories deal with problems, to a large extent specific to their respective geographical areas.

In general, all the laboratories are equipped for undertaking applied research, including developmental work. They also undertake surveys of industrial raw materials and research on their beneficiation, testing and standardization. Many problems of industry, and even of pure science, are multi-disciplinary in character, and require for their solutions the knowledge and techniques of more than one branch of science and call for team-work. CSIR laboratories provide facilities for such team-work.

CSIR has completed more than sixty three years of its existence. Nourished, fostered and supported since its inception, by the successive Governments, CSIR today symbolizes a culture that links science with society through technology and industrial manufacture. Men of vision and values have shown the path and built CSIR to its present strength, ethos and culture. As the nations's largest holder of intellectual property rights (IPR), on patents CSIR leads the way for protecting traditional knowledge while adding to the new IPR capital.

CSIR's expertise and experience currently is embodied in about 4635 active scientists, recognized nationally & internationally, who are support by over 8349 technical personnel, and over 5309 administrative & other support personnel working in an infrastructure built over the years. CSIR has served as a spring board for scientific & technological activities in a wide variety of areas. CSIR has helped usher India into a scientific milieu, creating and nurturing talent in science, innovation and technology. It has spawned many organizations, many disciplines and most importantly has served as a nursery and training ground for most of India's talented scientists and technologists. CSIR has also promoted excellence in science and is the only S&T organization which nurtures and supports human-tech from 16-65 years of age through numerous schemes on human resources for scientific research.

The Tenth Five Year Plan (TFYP) was formulated against the backdrop of high expectations from the S&T sector expressed by the highest echelons of government arising from many enviable scientific achievements, and successful developments in S&T sectors, coupled with the government's resolve to plan for a GDP growth rate of 8%. This brought in a responsibility and a challenge as also it provided an opportunity to the S&T system to prove its mettle! CSIR being amongst the large research organizations in the industrial sector has an added responsibility of helping the industry to achieve higher growth rates and become competitive globally.

The guiding principle for CSIR during the Tenth Five Year Plan (TFYP) is inherent in its mission, i.e. to provide scientific industrial R&D that maximizes the economic, environmental and societal benefits for the people of India. CSIR activities and programmes in the TFYP were operated through following six schemes of which five were continuing from Ninth Plan and one scheme namely ICT Infrastructure & Renovation & Refurbishment (IRR) introduced as a new scheme in the Plan:

i. National Laboratories
ii. National S&T Human Resource Development
iii. Intellectual Property & Technology Management
iv. R&D Management Support
v. New Millennium Indian Technology Leadership Initiative (NMITLI), and
vi. ICT Infrastructure Renovation & Refurbishment

Among these schemes, National Laboratories under which major R&D programmes/projects have been undertaken was the major scheme accounting for more than 75% of CSIR Plan funds.

The Tenth Five Year Plan programmes and activities of CSIR were formulated on the recommendations of a Working Group constituted by the Planning Commission in 2001 under the Chairmanship of Secretary DSIR & DGCSIR. The Working Group, keeping in view the broad objectives of the national development and the role of S&T in general and CSIR in particular, had recommended broad based programmes for implementation by the laboratories. Adopting a sectoral approach the programmes were classified into thirteen broad sectors viz, Aerospace; Biology & Biotechnology; Chemicals; Earth Resources & Natural Hazards Mitigation; Ecology & Environment; Electronics & Instrumentation; Energy; Food & Food Processing; Healthcare, Drugs & Pharmaceuticals; Housing & Construction; Information Dissemination and Products; Leather; Materials, Minerals, Metals and Manufacturing. Under each of the Sectoral Plans, the Working Group had broadly recommended major projects/programmes.

The Working Group had recommended budgetary support of Rs. 4545 crore for the Plan. The recommendations of the Working Group were examined by the Planning Commission appointed Steering Committee on Science & Technology chaired by the then Principal

Scientific Adviser to the Prime Minister and it finally recommended a Plan budgetary support of Rs. 2430 crore only.

Based on the premise of the Plan outlay of Rs. 4545 crore, targets were set for CSIR as a whole and given in the Report of the Working Group. However in view of the down-sizing of the budgetary support, CSIR limited its projects/programmes to fifty five initially and later added one more project. Besides, continuation of Ninth Plan schemes with new components, a new scheme on ICT Infrastructure Renovation and Refurbishment akin to modernization scheme was also initiated.

1.2 APPROACH, STRATEGY & POLICY REFORMS DURING TENTH FIVE YEAR PLAN

The activities and the role performed by CSIR were in conformity with the then prevailing economic, social, industrial, and R&D environment conditions nationally & internationally. The national target of GDP growth of 8% in Tenth Five Year Plan required organizations to re-examine their strategies & adopt innovative approach. CSIR, as a dynamic responsive organization as ever in the past, quickly responded to the need. The CSIR plans were drawn up based on the careful assessment of the needs and the opportunities, development of core competencies and R&D facilities.

The rationale for drawing programmes were based on the premise that pre-competitive research being public goods, need to be largely financed through public funding. In the selection of the programmes the guiding principles were based on:

- High levels of novelty and innovativeness;
- Global competitive positioning in science and / or technology;
- Potential industrial, economic, strategic, societal benefits that could be captured and accrue to the Indian economy.

As CSIR has a well knit network of laboratories across multi disciplines, a conscious decision was taken to implement programmes in network mode through establishing synergy within the vast, often niche, competencies available with the laboratories. The knowledge networking within and across CSIR laboratories was effected through identification of network programmes and projects.

The network projects, thus evolved, for the Tenth Five Year Plan period consisted of:

(a) target oriented core network R&D projects, and

(b) building of capabilities and facilities.

Through these projects substantial increase in value through conscious inputs of S&T in knowledge driven areas was targeted. The Task Forces were constituted for each sector which formulated network proposals and also implemented the same. These proposals were scrutinized critically by the Planning Commission for approval of budgetary support and implementation by CSIR laboratories.

The national S&T Human Resource Development programme was launched aiming to bring back the glory of science and if that establish, nurture and sustain institutions of higher learning to produce specialized scientists/engineers and technologists in all disciplines of S&T in the country. Under this scheme, five programmes were identified and operated, viz. (i) CSIR programme on youth for leadership in science (CPYLS), (ii) Shyama Prasad Mukherjee Fellowships, (iii) Fellowships in trans-disciplinary areas, (iv) Entrepreneurship support to research scholars, and (vi) Faculty training and motivation and adoption of schools and colleges by CSIR labs.

CSIR has made long strides in Intellectual Property generation and protection and it continues to be the top patents securing public funded R&D organization in India and abroad. During the years 2002-05, CSIR filed 2511 Foreign and 1649 Indian patent applications. The scheme on Intellectual Property and Technology Management was further strengthened to enhance the volume of intellectual property generated by CSIR to share the best innovation and technology management organizationally and with the Indian S&T community at large.

CSIR operated a New Millennium Indian Technology Leadership Initiative (NMITLI) scheme considered to be India's largest public private partnership R&D programme. Under the scheme there are 42 projects involving 65 industrial partners and 222 research groups to capture global technology leadership position and development of technology through consortia of the "best" academic/R&D and industrial partners. This scheme is aimed to deliver cutting edge technologies that are globally competitive, sustainable and eco-friendly to provide India a global leadership position in select industry.

The ICT Infrastructure Renovation & Refurbishment Scheme has been initiated under the TFYP to provide support to the high end technology in developing scientific management grid solutions. Upon completion of this scheme it will provide necessary ICT infrastructure for scientists/technical staff to manage activities of CSIR in more efficient and effective manner.

The various functional units/divisions located in CSIR Headquarters provided the R&D Management support to the national laboratories through the scheme. It provided support to the laboratories for human resource development, international scientific collaboration, publicity and public relations, performance appraisal, scientific audit etc.

The globalization of economy, lowering of free trade barriers, and competition driven by innovation has changed the way of managing R&D organization and doing R&D. In order to be competitive in the new era of knowledge driven economy CSIR has brought significant policy reforms & initiatives between 2002-2005. Some of the reforms and initiatives are listed below:

1.21 Performance Appraisal Boards

CSIR restructured its organizational structure to introduce a systematic and transparent procedure for evaluation of performance of its constituent laboratories based on which decisions would be taken to (a) intensify support to successful areas, (b) renew the mandate to keep pace with global trends, and (c) integrate institutions to optimize deployment of resources for maximum output, or close in full or in part those establishments which are no more relevant. In all these, the guiding principle was that CSIR should be doing internationally competitive research in critical areas whether in fundamental sciences or industrial innovation. A new organ, called the Performance Appraisal Boards (PABs) was thus introduced to critically review the performance of each laboratory once in every three years. Specific Board comprising representatives of stakeholders, individual experts from academia, industry etc. was constituted for each laboratory; and its tenure was limited to carrying out the appraisal of the laboratory. The first set of performance review completed prior to launching of TFYP had *interalia* recommended: refocusing of S&T activities to meet the perceived and emerging customer and stakeholder needs; devising a proper balance between the S&T activities in the laboratories; global positioning in the niche areas; supra institutional projects- every laboratory to have at least one major flagship project in which the majority of groups in the laboratory participate; enhancing the science base and output of the laboratories; consolidation of core competencies of Central Fuel Research Institute and Central Mining Research Institute and Networking of diverse constituents, interlab / intralab, with R&D organizations and other constituents. CSIR has initiated steps to implement the findings and recommendations of the PABs.

1.22 Setting up of Human Resource Development Centre (HRDC)

Globalization has brought in its wake, challenges which transcend national boundaries. Competition is severe, necessitating high performing organizations, staffed with possessed and motivated workforce to continually sharpening their functional and managerial skills through specially customized training programmes. Realizing the need of rejuvenating the skills of CSIR human resource, a new center called HRDC was set up at Ghaziabad during 2002 with a mission " to promote professional and holistic human resources management groups both at headquarters and in each laboratory and evolve long term human resources development plan for professionalizing R&D management and support". During these years HRDC has conducted a variety of training programmes for development/enhancement of functional and personal competencies/skills of CSIR staff. Based on Training Need Analysis conducted on different groups in few laboratories, HRDC has designed a number of induction, refresher, orientation programmes as well as many specialized workshops.

1.23 Setting Up of Recruitment & Assessment Board (RAB)

CSIR modified the Recruitment & Assessment Promotion Rules for Group IV Scientists and set up Recruitment & Assessment Board (RAB) to organize the assessment of the CSIR scientists centrally to bring in uniformity across the laboratories and among the subject clusters.

1.24 Reinventing CSIR

Realizing the need for documenting and valuing the impact of contributions made by CSIR in the national development effort, the Council decided to assess the impact and benefits accruing from its pursuits to the society, economy and environment. Accordingly, a Committee under the Chairmanship of Dr.Vijay Kelkar, Adviser to Finance Minister, was set up in June 2003 to assess and value the socio-economic-environmental benefits arising from CSIR's R&D outcomes and S&T activities. The Committee systematically undertook in-depth studies and evolved a methodology, a first of its kind, to value publicly funded organizations. It made several far reaching recommendations to enhance value of CSIR's contributions.

1.3 OVERVIEW OF PERFORMANCE DURING THE TENTH FIVE YEAR PLAN

CSIR has made significant contributions during the first four years of TFYP in a wide spectrum of activities, which span from creation of public goods, private goods, social goods and strategic goods. While maiden flight of SARAS was a landmark in CSIR's contributions to herald the civil aviation industry in the country, the discovery of a new molecule, as a potential drug for cure of deadly disease of tuberculosis, CSIR's instant response to alleviation of hardships of Tsunami's victims were a few of the major contributions in other spheres.

CSIR lead the Team India initiative for setting up the first ever Traditional Knowledge Digital Library (TKDL) to provide a search interface to retrieval of traditional knowledge information on international patent classification (IPC) and keywords in multiple languages. Database has been created on traditional medicinal formulations comprising 13 million A4 size pages of data on transcribed 62000 formulations in Ayurveda, 60000 formulations in Unani, and 1300 formulations in Siddha. TKDL has been receiving wide international coverage.

As a socially conscious organization CSIR continued its effort to provide the S&T needed for the masses. During the plan, it promoted employment generation on one hand and developed diverse technologies to add to the quality of life on the other hand. These technologies include: ceramic membrane based removal of arsenic and iron from contaminated ground water; pesticide removal unit for producing potable water, free from organic pollutants; setting up of Reverse Osmosis (RO) based desalination plants in villages; hand operated microfiltration units (with 3 litre /minutes discharge rate) capable of providing bacteria & virus free water; Ultra Filteration (UF) membrane based technology requiring no electricity and chemicals to remove germs, cysts, spores, parasites, bacteria, Cryptosporidium, endotoxin etc.; low sodium salt from bitterns in place of pure sodium chloride; which is being recommended to patients suffering from hypertension;etc. CSIR response to Tsunami victims had shown its scientific and technical skills to mitigate the hardship of those survived. The initiatives taken by various CSIR laboratories could provide food, drinking water & shelter to the survivors.

Other notable S&T achievements are as under:

HANSA

The two seater all composite trainer aircraft HANSA designed and built by NAL has been certified by DGCA for day and night flying. The know-how was licensed to a private sector firm for commercial production. So far eight aircrafts have been manufactured and delivered to various flying clubs through DGCA and four aircraft are under fabrication.

SARAS takes to skies

SARAS, India's first indigenously developed, multi-role civilian aircraft took its inaugural test flight to skies at 8.20 am on Sunday, 22nd August, 2004. Till September 2006, the prototype-1 has made 60 test flights. It would require 500 hours of successful tests for the certification from DGCA. SARAS will serve as a multi-role aircraft with feeder airline and air taxi operations as its primary roles. It would also be used as executive transport and light cargo carrier, in remote sensing, as aerial research vehicle, coast guard, border patrol, air ambulance and other services. It can take off and land from short semi-prepared runways and is therefore ideally suited for operations in difficult terrains and would help in providing connectivity, especially in the North East India. With potential for such multiple roles, it is expected that SARAS will usher in a vibrant civil aircraft industry in the country in the coming years.

Head up display (HUD) for Light Combat Aircraft

HUD, which occupies the prime location in LCA cockpit and provides the pilot with essential flight information, navigational and target/weapon release cues etc., has been integrated successfully in LCA-TD2 and flights have taken place with CSIO developed HUD on board. The CSIO-HUD has superior features in comparison to those of international suppliers.

High efficiency space TWT

TWT is one of the most complex and expensive components of any communication system either being used in space or ground. There has been a growing demand for high power, high efficiency C-band and Ku-band space TWTs to meet the new emerging requirements of the satellite communication systems. CEERI designed different components of the space TWTs using in-house developed software packages.

Special glasses

Technology for optical glasses are guarded world over. CSIR has established its first glass manufacturing unit at CGCRI and has developed more than four hundred different types of special glasses for use in mirrors in telescopes, reflectors in satellites, tracking robot movement, radiation shielding glasses to provide protection from harmful radiations. These are being customized to meet the requirement of strategic sectors such as space, atomic energy etc.

1, 1', 1'' – Tris 4'-hydroxyphenyl ethane (THPE).

NCL has developed an alternative novel route for synthesis of THPE, a branching agent used in the synthesis of polycarbonates, a high performance engineering polymer. This process has been licensed to a major producer of engineering for commercial production. The product is being exported to USA. The THPE production and export crossed 500 tonnes and thus it has become the second largest producer in the world.

Optical fibre amplifier

For the first time in India, an optical amplifier for light wave telecommunication network has been developed by CGCRI using erbium-doped optical fibre (EDF) and power semiconductor pump laser source. This device has the potential for use in the propagation of "Fibre to Home" technology in the country.

2-Methlyallyl sulfonic acid sodium salt and 2-acrylamido-2-methyl-1-propane sulfonic acid

These are speciality monomers that find applications in the acrylic fiber industry for imparting dye-affinity to the fiber. Polymers prepared by using later monomer (AMPS) are also extensively used in the Enhanced Oil Recovery (EOR). Similarly it is used in water treatment chemical and in preparation of specialty polymers. M/s Vinati Organics Limited (VOL), Mumbai, sponsored the project to NCL for development and transfer of the technology for these two monomers. NCL successfully developed the process for both the monomers, prepared Basic Enginering Package for 750 TPA SMAS and 1000 TPA AMPS plants and helped in commercializing the plant. The plant with more than 80% of its production being exported, M/s Vinati Organics has become the third largest global producer.

ISFET (Ion-Sensitive Field-Effect Transistor)- based glucose biosensor

CEERI has developed ISFET based glucose biosensor. This biosensor comprises an ion-sensitive field-effect transistor (ISFET), which is a metal-oxide-semiconductor field-effect transistor (MOSFET) with the metal gate replaced by a chemical membrane (SiO_2-Si_3N_4) responsive to hydrogen ions, producing a solid-state pH-micro-sensor. This has the advantage over conventional biosensor in terms of smaller size, robustness, easy cleaning, minimal need for maintenance, and fast response.

Tractors

MERADO/CMERI has developed design know-how of 35 hp Tractor with the novelty of deep cultivation capacity, efficient soil gripping, increased carrying capacity while climbing, maintaining very good speed while running in roads, economy in fuel consumption and above all minimum maintenance cost. The know-how has been transferred to M/s International Tractors Limited, Hoshiarpur for commercialization, and marketed as Sonalika Tractor. The tractor is suitable for medium and large holdings.

CMERI has also developed a low HP tractor having a new finger tip single lever automatic depth-cum-position control hydraulic system for better working on mounted implements. The unique characteristics of the design are full fledged automatic hydraulic system and optimum control location. It is cheaper and suitable for medium and small farmers.

Oil expellers

MERADO/CMERI has developed 1-TPD Oil Expeller, to replace the traditional ghanis to produce pungent mustard oil. Expellers of 1 TPD capacity are ideally suited for employment generation in semi-urban and rural areas.

A complete range of modern oil expellers, capacities ranging from 6 to 20 tonnes/day suitable for the efficient extraction of oil from mustard, groundnut, cotton seed and other oilseeds have been developed. The oil expellers offer the advantages of higher oil extraction, lower residual oil in cake, longer life of critical components and better quality of oil and cake. The know-how has been released to a number of manufacturers.

Malaria

➲ CDRI has identified a synthetic antimalarial trioxane compound 97/78 as a substitute to the naturally occurring artemisinin. The compound exhibited significant antimalarial activity in pre-clinical studies and safe profile in regulatory pharmacology and systemic toxicity in rodent models. A collaborative research cum licensing agreement has been signed with M/s IPCA. Laboratories, Mumbai for development of the drug. Another promising anti-malarial trioxane compound 99/411 is under pre-clinical evaluation.

- NIO has prepared the crude extract by the enzyme-acid hydrolyzing process from a marine organism (mussel) which shows potent anti-malarial activity *in vitro* cultures of *Plasmodium falciparum* in human erythrocytes. The molecular entities responsible for anti-malarial activity were isolated & characterized and named as NIO-l and NIO-2. These molecules present themselves as promising candidate drugs for malaria and may be used in conjunction with conventional drugs. The active compound is relatively cheap to obtain and can readily be prepared in bulk without killing the mussel. The Mumbai-based company Shreya Life Sciences has been licensed to commercialize the drug.

Cancer

- IICB has discovered and isolated a compound from the leaf of the betel plant (*piper betel*), which induces death of cancer cells in chronic myeloid leukemia (CML), a type of cancer that attacks white blood cells. The compound, has the same structure as chlorogenic acid (*Chl*), and kills cancerous CML cell lines without harming normal cells. Experiments were restricted to *in-vitro* (laboratory) studies on commercially available CML cell lines and primary CML cells from patients. *In-vivo* studies were limited to nude mice model that were transplanted with human CML xenografts.
- RRL-Jammu has isolated a natural compound from *Boswellia* species, as well as alternatively prepared its semi-synthetic compounds for cancer of colon, prostrate, liver, breast, central nervous system (CNS), leukemia and malignancy of other tissues, including ascites and solid tumors. The pharmaceutical preparation has shown lower toxicity and therefore, would be well tolerated by the patients. The chemically synthesizable, economically viable, commercially high yielding compound from *Boswellia* sp. is also intended to provide analgesic and sedative effects to the patients suffering from advanced malignancy, in sharp contrast to others where prophylactic use of psychotherapeutics and anti-emetics are often recommended during chemo-cum-radiotherapy.
- RRL-Jammu has identified the cytotoxicity and anti-cancer activity of an essential oil, alone and also in combination with pharmaceutically acceptable or other carriers, of a new chemotype from *Cymbopogon flexuosus* (Nees ex Steud.) Wats [RRL(J)CF HP] for prostrate, lung, colon, cervix, ovary, breast, leukemia, liver, neuroblastoma, oral cavity cancer, and ascites and solid tumors. The oil regressed ascites and solid tumors in mouse tumor models.
- RRL-Jammu has developed a herbal formulation from the plant extract of *Cedrus deodar* for the treatment of cancer. The synergistic composition of lignan and pharmaceutically acceptable carriers is used for inhibiting growth of various human cancer cell lines selected from breast, cervix, neuroblastoma, colon, liver, lung, mouth, ovary and prostate tissues.

Cardiovascular disorders

- IMTECH has developed a process for high-level production of recombinant Staphylokinase. Staphylokinase is produced intracellularly using genetically engineered strain of *Escherichia coli*. Recombinant Staphylokinase is produced at high level using batch fed fermentation and purified protein is recovered after cell lysis and column chromatography. Patents for this technology have been filed in several countries to protect the IPR. The technology is currently being scaled-up with a commercial partner.
- IMTECH has standardized a laboratory-scale process for the preparation of clot-specific streptokinase. The process entails the culturing of *E.coli* carrying appropriate plasmid DNAs encoding for either recombinant natural-type streptokinase or its different engineered constructs, followed by cell-lysis refolding of polypeptides to their biologically active states, and their isolation at approx 85-95% purity by chromatographic

means. The technology for preparation of clot specific streptokinase has been transferred to M/s Nostrum Pharmaceuticals Inc., USA.

Diabetes miellitus

- IGIB through a public-private partnership with M/s Bharat Biotech Industry Ltd. (BBIL), Hyderabad, has commercialized two important formulations: one as a brand name Regen-D™ -60 for skin graft and burn injuries, while the other, Regen-D™ -150, meant for diabetic foot ulcer. Diabetic foot ulcer is a major complication of diabetes. In general, diabetic foot ulcers are difficult to heal, become readily infected and gangrenous and frequently lead to amputation. This work has been recognized by a national award (Technology award, 2006).

Liver disorders/dysfunctions

- RRL, Jammu developed a single plant based standardized Hepatoprotective agent useful for the treatment of liver disorder such as alcoholic & viral cirrhosis. The process of extracting the formulation has been standardized on the basis of two marker compounds. The technology has been transferred and demonstrated to M/s Medley Pharmaceuticals Ltd., Mumbai. Medley has already released the product in the market and has named it as LIV-1.

Osteoporosis

- CDRI has developed the compound 99/373 that has shown better anti-osteoporosis activity than raloxifene, during pre-treatment studies on rat. The compound is devoid of any major CVS and CNS side effects on mice and rats found safe in 28 days toxicity studies. It has high therapeutic value.
- RRL, Jammu has developed a process for the extraction of an enriched extract of calcitriol from a plant found in South India which accumulates this compound in trace amounts. Calicitriol is physiologically active form of Vitamin D3, which plays an important role in uptake of calcium in intestines and bones. The drug has therefore an important role in osteoporosis and skin disorders like psoriasis. The technology for the production of the extract has been scaled up to the pilot plant scale and transferred to M/s Genova Biotechniques, Hyderabad. The company has already started the production of the extract for marketing in India.

Stroke

- CDRI has developed a herbal medicament which has shown promising anti-stroke activity along with antioxidant and anti-inflammatory properties on pretreatment in rat. It has been licensed to M/s Themis Medicare Limited, Mumbai under a collaborative development cum-license agreement for the development of the product.

Diagnostics

- CDRI in collaboration with Department of Biotechnology has developed and evaluated PCR based Tuberculosis Diagnostic Kit for its sensitivity and specificity in clinical samples. The process know-how for the preparation of specific DNA probes and oligonucleotide primers were developed and licensed to M/s Biotron Health Care Ltd., Mumbai for manufacturing and marketing the product as PCR based Tuberculosis diagnostic kit.

Drug delivery systems

- IICT has developed technology for oral delivery of insulin and Hepatitis B vaccine. These new inventions are a boon to the diabetic population as reduction in blood glucose levels are comparable to that observed with the injectable preparation of insulin. Similarly, single oral dose of Hepatitis B vaccine not only generated anti-body titres comparable to the injectable Hepatitis B vaccine but with an added advantage in its convenient administration to infants and children.

Bioinformatics in health & drug development

- IGIB has developed world-class facilities and software for use in healthcare field. Geno-cluster is a Bio R&D Software tool for facilitating new drug discovery. It comprises a string of products that will enable researchers and pharmaceuticals companies to discover drugs/targets/biomarkers quickly and at low cost. The components of geno-cluster are :
  - **GeneD'CFER** is a novel software tool for gene identification and structure function studies based on evolutionary conserved peptides.
  - **Proteome Calculator** is a software product for comparative proteomics and genomics. This software is powerful computational applications to study several proteomes at one go by performing set theory operations like union, intersection, difference and inverse.
  - **SEAPATH** is a unique software tool specially designed to overcome functional problems for prediction of virulent proteins.
  - **PLHost** is user friendly and fast tool for annotation and homology of small peptide and does not use complicated sequence alignment tools and hence is a more convenient method. It gives accurate prediction of functional sequence.

Development of high flux, thin film composite (TFC) reverse osmosis membrane

CSMCRI has successfully developed Thin Film Composite (TFC) reverse osmosis (RO) high flux membrane in-house. The indigenously developed membrane is suitable for treatment of tertiary treated sewage water. One million liters/day capacity plant has been commissioned at Chennai Petroleum Corporation Ltd (CPCL), Chennai. The use of this new membrane, which is non-biodegradable, and the ability to work over a wide pH range, would reduce capital investment and operating cost greatly.

Purioin FnP

NCL has developed, demonstrated and transferred a Ultra Filtration (UF) membrane based water purification technology which removes germs, cysts, spores, parasites, bacteria, cryptosporidium, endotoxin, Pseudomonas viruses of Hepatitis A, E. The filtration unit requires no electricity and chemicals to filter water. The filter unit can be operated at low pressure viz., running tap water. The unit has been granted US patent and the technology has been transferred to M/s Membrane Filters (India) Pvt. Ltd.

Cultivation of elite variety of *Jatropha curcus* and production of bio-diesel of international specification from the oil

CSMCRI has successfully cultivated elite varieties of *Jatropha curcus* on marginal land to assess practically realizable seed yields. Further, the lab has developed a simplified process for production of biodiesel confirming Euro 3 specifications for free fatty acid methyl ester. A third objective is to identify outlets for by-products to enhance for overall value of the seed and thereby make cultivation of the plant more remunerative.

While biodiesel complying with Euro 3 specification is produced in Europe from rapeseed oil, this is the first time that such biodiesel has been made from Jatropha oil. The biodiesel has been evaluated at Daimler Chrysler AG and found to be matching all specifications. The cetane number has been established to be 58.5. Larger lots of biodiesel are now being made for evaluation in India in a Mercedes Benz car. Orchards are simultaneously being raised in Orissa (Huma & Mohuda villages) and Gujarat (Chorvadla village) to make elite germplasm available in sufficient quantity so that cultivation can subsequently be taken up in larger (100-200 hectares) tracts of wasteland.

Computer-aided microscopic inspection system for medicinal plants

A computer-aided microscopic inspection system, which avoids some of the shortcomings of the conventional microscopic inspection methods, has been developed. The system, HERBAS (Herbs Authentication System) consists of a computer, microscope, digital camera, printer and custom-developed application software. The application software running on the computer allows the user to capture the microscopic images through the digital camera and utilizes them appropriately.

Nutrient dense food for infants and children

CFTRI has developed weaning food for infants by incorporating amylase rich flour particularly from finger millet. A small quantity of malt flour (about 5%) could be mixed with high bulk foods prepared by popping, roller drying or extrusion cooking. By this approach their texture, nutrient density and also bioavailability of the major and minor food constituents could be improved.

Novel method for measurement of texture of cooked grains

CFTRI has developed a simple device and a method for direct measurement of cookability of grains based on the measurement of 'spread area' of cooked grains. It is a new concept for measurement of textural softness of cooked grains particularly that of cooked dhal and rice. The methods available currently for measurement of cooking quality are either subjective or based on sophisticated instrumental analysis. This method also eliminates the subjectivity in testing the textural softness. Being a simple device, it can be adopted for assessing the cookability of grains for routine laboratory evaluation.

Dehulled finger millet

CFTRI has developed the process of decortication of the Finger millet, wherein the texture of the endosperm of the millet is hardened by hydrothermal treatment and the grains are decorticated in a cereal milling machinery. Finger millet (*Eleusine coracana*) or *ragi* is an important nutri-cereal. The decorticated grains, with appealing light cream color resemble native grains in shape and size, cook to a soft edible texture within 5-7 min as discrete grains and contain nutrients such as protein, carbohydrates, lipids, dietary fiber, calcium and polyphenols.

Palm oil mills of 2.5 tonnes Fresh Fruit Bunches (FFB)/hr capacity

RRL, Trivandrum has developed technology package for processing 2.5 tonnes of Fresh Fruit Bunches(FFB)/hr of Oil Palm for extraction of palm oil. It is state of art technology package and is globally competitive cost-wise.

Swing technology to process fresh /dry spices for essential oils, oleoresin and active principles

RRL, Trivandrum has developed the Swing technology as a novel approach in the global context to process fresh spices to produce premium quality essential oils, oleoresin and active principles with 20-30% higher yield as compared to that of dry processing. The technology is further tailored to handle dry spices also. The technology has been licensed for commercial production to 5 companies. One commercial unit for processing fresh ginger based upon this technology has been established in Meghalaya.

Enzymatic degumming of rice bran oil

IICT, has developed technology package for enzymatic degumming. Enzymatic degumming step catalyses conversion of even non-hydratable phospholipids into water soluble lysophospholipids which are removed by centrifugation yielding degummed oil with very low phosphorous. This oil when subjected to refining process yields good quality rice bran oil rich in micronutrients. This enzymatic degumming process offers advantages of being environment friendly, less energy intensive and reduced water consumption. The technology has been transferred to 18 rice bran oil refineries and also licensed to 8 project engineering companies spread over 9 states.

Vegetable salt

CSMCRI has developed a new technology for low sodium vegetable salt which would make such salt more affordable. Sun dried *Kappaphycus* has significant quantities of salt that has been characterized to be largely KCl. This new all vegetable salt has been named as Saloni K.

CSMCRI has also developed a simple technology to obtain white, naturally free flowing salt having 85 -90% NaCl , 5-8 % KCl, 0.2 to 0.4 % Ca, 0.02 to 0.08 % Mg, 2.2 to 3.4 % SO_4, 7 to 10 ppm Iodine, 1 to 2 ppm Copper, 3 to 10 ppm Iron, 0.2 to 1.0 ppm Manganese, 0.5 to 5.0 ppm Zinc, etc. The technology has been transferred to two industries.

Gene silencing – A hope for cancer control

CCMB has studied small non-coding RNA commonly known as micro RNA and anti-sense RNA derived from genes and transgenes, which regulate gene expression in organisms ranging from nematode to human. Gene silencing in plants and animals can be achieved by interfering with gene activity through the small RNA molecules, the 'interfering RNA' (RNAi), at specific loci during the conversion of euchromatin to heterochromatin. The disruption of RNAi interference mechanism in living cell blocks the formation and maintenance of heterochromatin, eventually leading to disruption of specific chromosome regions. The diseases involving cell division and cell proliferation, such as various types of cancers, appear to be controlled by heterochromatin formation and its functioning. Therefore understanding the role of RNAi intervention in these processes might pave a way to use RNAi as a possible therapy for cancer and other related diseases, which involve cell cycle controls.

Biologically derived HIV-1 protease inhibitors

NCL has isolated first biologically derived molecule ATB 1 that inhibits HIV-1 protease. The mechanism by which this inhibitor acts makes it especially robust to mutations of HIV. The isolated inhibitor has an amino acid sequence that shows no similarity to existing inhibitors, and represents an exciting new class of inhibitors with important implications for AIDS therapy. HIV requires an enzyme called HIV-1 protease in order to multiply. Thus, this enzyme is an excellent target for developing drugs against the virus.

Human genome diversity

CCMB has carried out studies on a large cross section of Indian population to understand their origin, evolution and migration. Mitochondrial hypervariable region I analysis of 4500 unrelated individuals belonging to 107 endogamous populations have resulted in 72 complete mitochondrial sequences, including 15% from Andamanese. The complete mtDNA sequences of Onges and Great Andamanese revealed novel mutational events in these two populations. The mitochondrial DNA sequences of the Onge and the Great Andamanese do not match with any other populations, including 6,500 samples covering the entire Indian subcontinent, thus indicating their origin. Novel mutations in the mtDNA of the Onge and the Great Andamanese have placed them in two unique branches in the human evolutionary tree. This study suggests that two ancient maternal lineages have evolved independently in the Andaman Islands in genetic isolation. This may be due to the initial penetration by modern humans of the northern coastal areas of Indian Ocean in their out-of-Africa migration about 50-70 thousand years ago. Analysis of Nicobarese mtDNA revealed that they belong to two lineages which are common in China, Malaysia, Myanmar and Thailand, suggesting their recent arrival from the east in the past 18000 years.

Identification of two candidate genes for schizophrenia and bipolar disorder

IGIB has carried out studies for Synaptogyrin 1 gene and MLC 1 gene**.** Chromosome 22q is one of the important regions repeatedly being implicated in schizophrenia. Synaptogyrin 1 (SYNGR1) associated with presynaptic vesicles in neuronal cells and MLC 1 gene, putative cation-channel gene, lying within 1 million base pairs of this marker, are potential candidate genes for schizophrenia (SCZ) and bipolar disorder (BPAD).

Synthetic peptide based nano tubes

IICT has developed synthetic peptide based nanotubes that have a wide range of futuristic applications. This new class of compounds could be used for delivering DNA material for gene therapy and also making biochemical sensors. Nanotubes would help in developing a new generation of "molecular machines" and would benefit polymer, materials and electronics industries. IICT has also developed modified peptide that show helicity using as few as three residues. IICT is the first to develop these unique peptides.

DNA marker tagged variety 'CIM-Arogya' of *Artemisia annua* for high artemisinin yield

CIMAP, has developed a novel, distinct, high herb and artemisinin yielding genotype of *Artemisia annua* through systematic marker assisted breeding followed by selection of uniform population. The plant *Artemisia annua* produces a sesquiterpenoid lactone endoperoxide named artemisinin, which is a promising antimalarial drug effective against

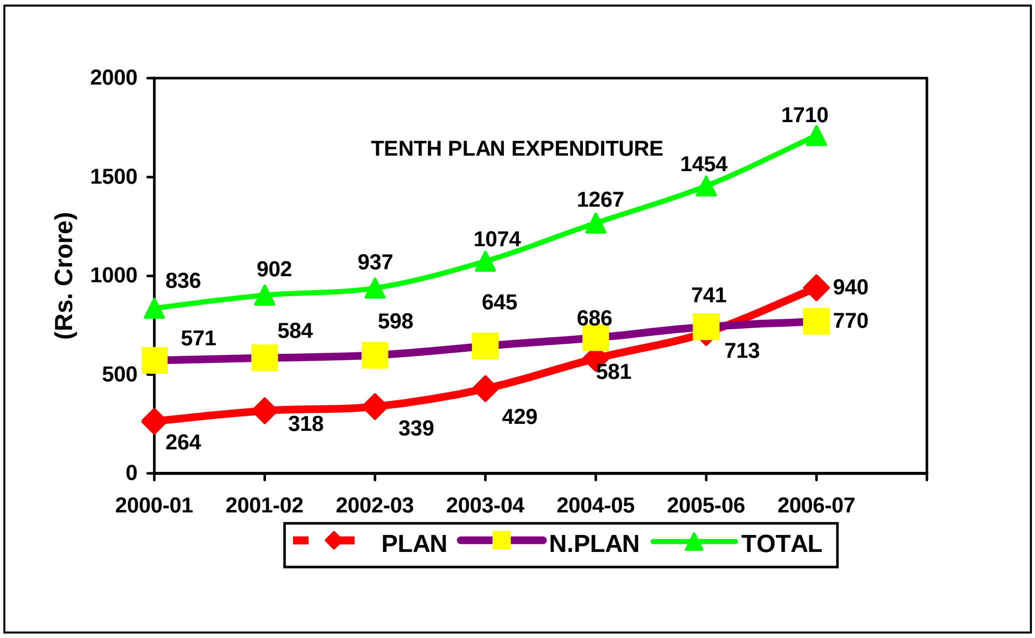
Plasmodium falciparum and *Plasmodium vivax* at nanomolar concentration. The genotype 'CIM-Arogya' possesses the traits of increased herb yield than the other check varieties and genotypes. CIM-Arogya produces higher biomass leading to high artemisinin yield.

1.4 SCIENTIFIC & INDUSTRIAL RESEARCH OUTPUTS

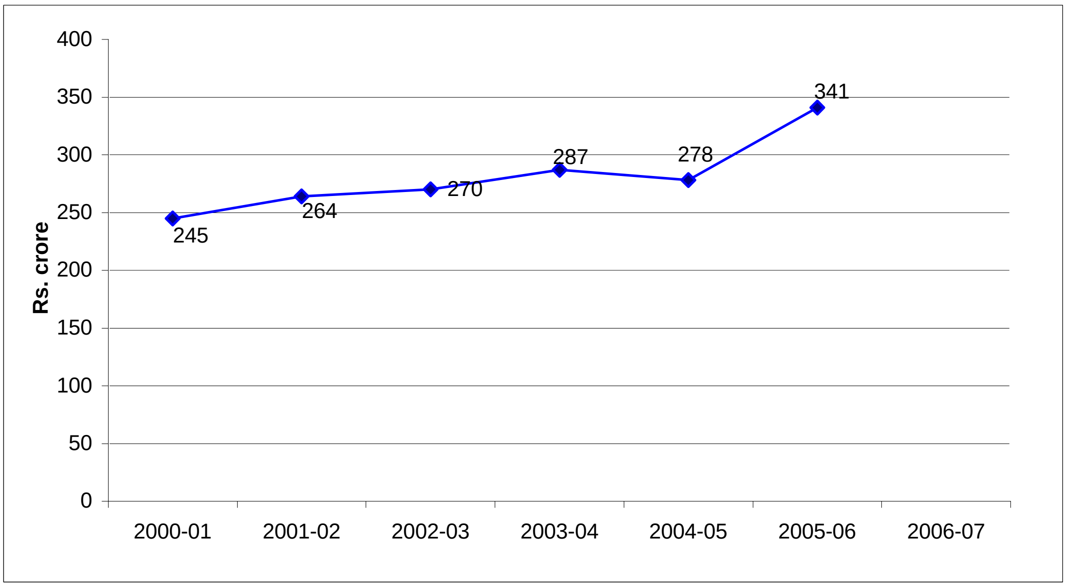
During the period the research outputs of CSIR have been commandable. It has emerged amongst the top three entities from the developing world in terms of PCT filing. US patents granted is considered as one of the indices in measuring the technology achievement of the countries. CSIR was granted 543 US patents during 2002-06. 62% share in the total US Patents granted to Indians excluding NRIs and foreign assignees belongs to CSIR. As a result of researches carried out in the national laboratories over 6885 basic research papers have been published in internationally peer reviewed journals with an average impact factor per paper of nearly 2.01 during 2005. For the period 2002-2006 (as on March 2006) the ECF generated was Rs 1178 crores and cumulative ECF is expected to touch over Rs.1550 crore at the end of the plan period i.e by 2006-07.

On the Financial Performance side, in the Tenth Plan, as against an approved plan allocation of Rs.2430 crore, a plan allocation of Rs.3261 crore was provided by the Planning Commission. As against these allocations the anticipated expenditure for Tenth Plan would be Rs. 3002 crore. The year wise progress of performance on above parameters is shown synoptically in the following pages.

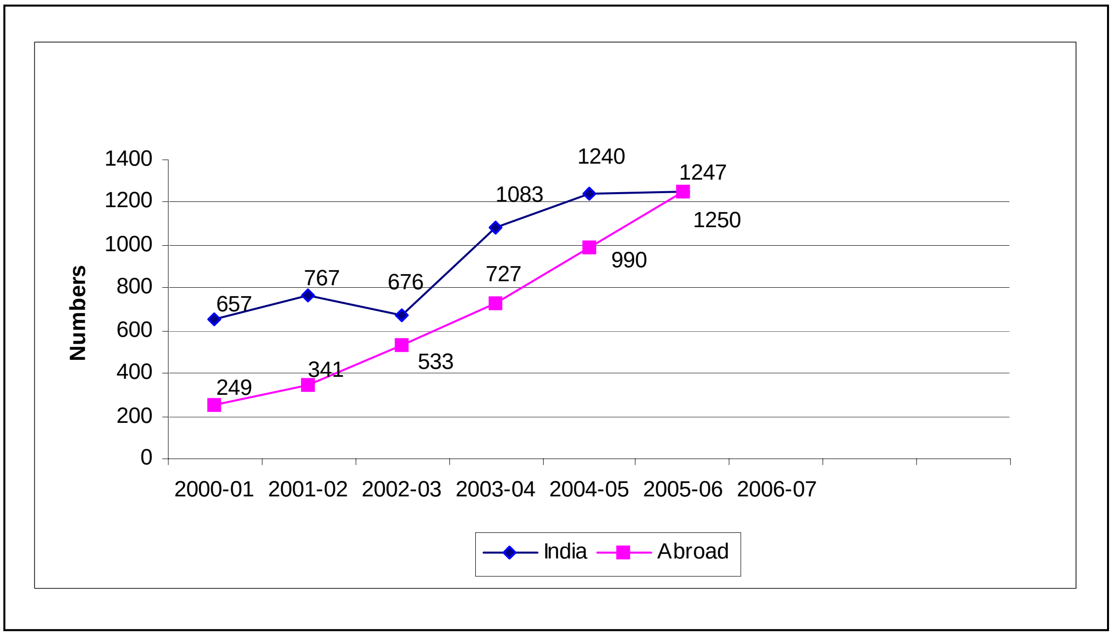
FINANCIAL PERFORMANCE OF TENTH PLAN



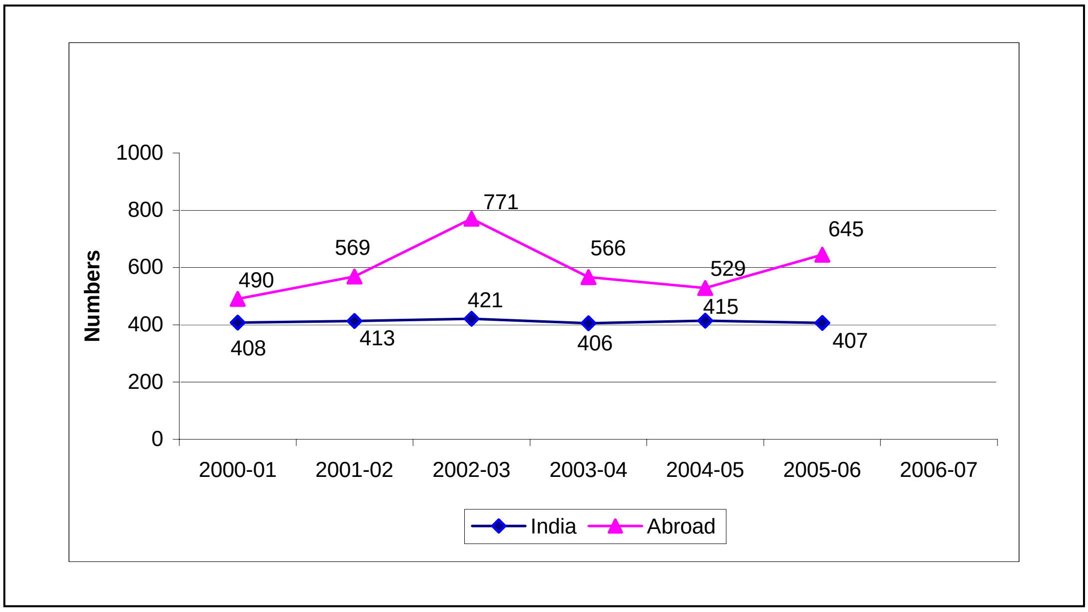
EXTERNAL CASH FLOW



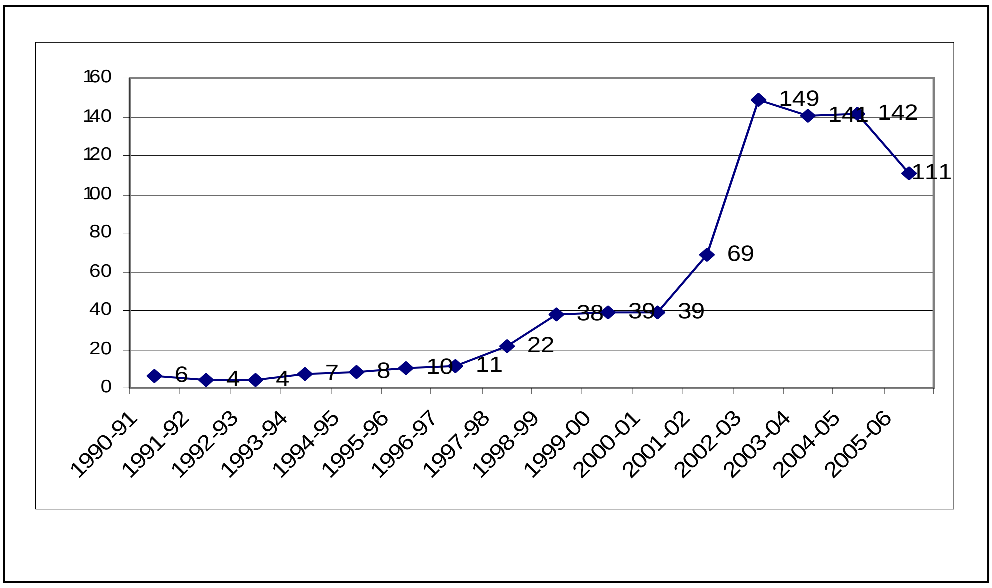
PATENT IN FORCE



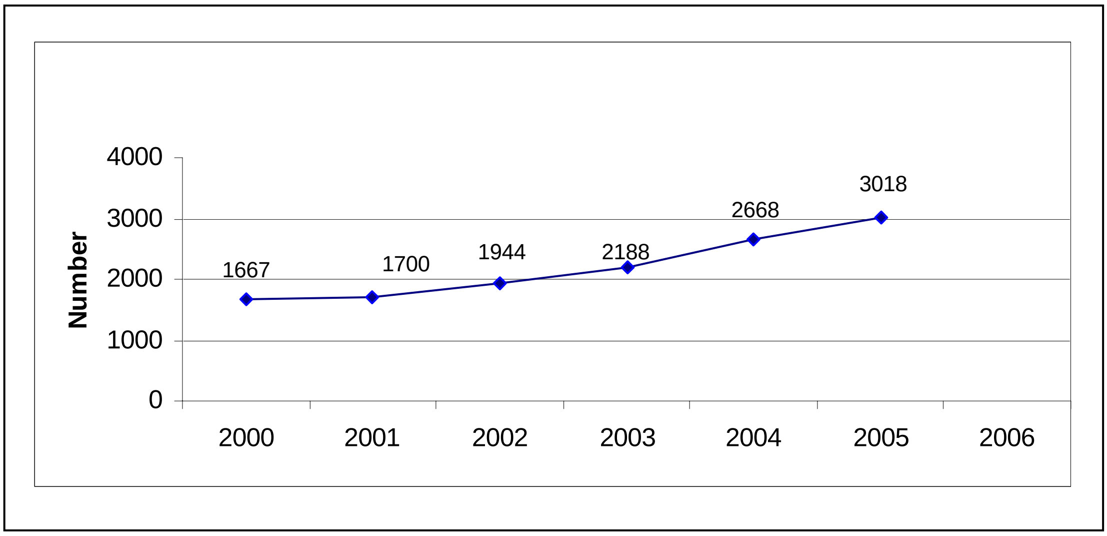
PATENTS FILED



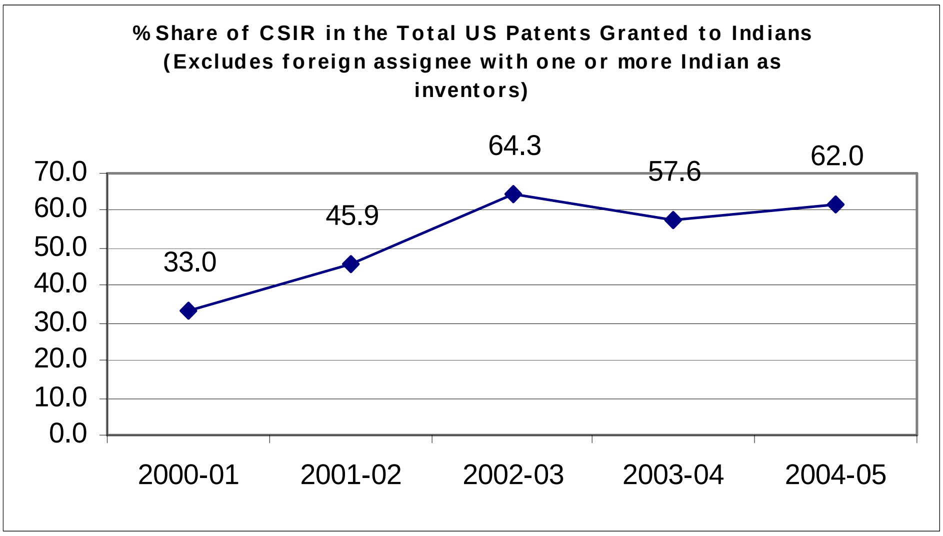
US PATENTS GRANTED TO CSIR



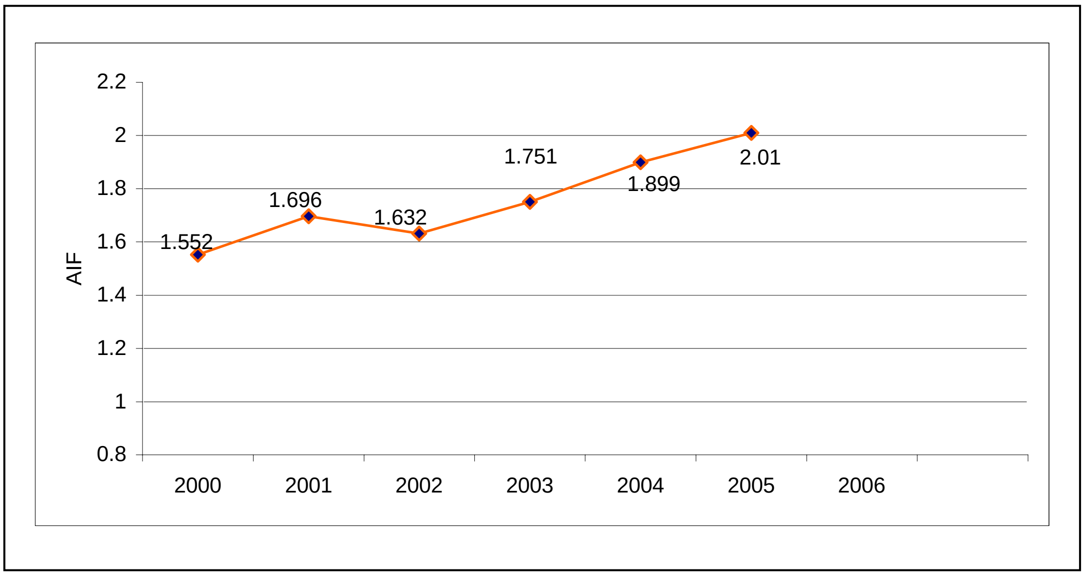
PAPERS CONTRIBUTED



% SHARE OF CSIR IN THE TOTAL US PATENTS GRANTED TO INDIANS EXCEPTING FOREIGN ASSIGNEES



AVERAGE IMPACT FACTOR



1.5 TRANSFORMATION OF CSIR AND ITS IMPACT

Over the last decade CSIR has transformed itself into a dynamic and vibrant S&T organization. With the various measures taken during the past decade, CSIR is surging ahead at a much faster pace. A few indicators which reflect the decade of transformation and its impact are summarized below:

Sl.No.	Subject	1995-96	2005-06
(OVERALL STATISTICS)			
1.	Overall Budget	Rs.412 crore	~ Rs. 1500 crore
2.	Funding for capital equipment for R&D (P5(3)	Rs. 25 crore	~ Rs.300 crore (includes purchases from Lab.Reserves, etc.)
3.	Ambition in terms of big projects (with a budget more than Rs.20 crore)	Nil	55 projects over 20 crores - largest over 200 crores
4.	CSIR labs working together in network projects form	Nil	56 networked
5.	No. of Labs	40	38 (only institutional systems in India to take a hard look at itself & close down/merge labs.
6	No. of outreach centres	90	39 (as above in terms of intent)
7.	No. of total staff	22,420	18,000 (slimming, consolidation)
OUTPUT FROM CSIR			
8.	No. of Scientific research papers in international journals (SCI papers)	1576	3018
9.	Quality of research papers as measured by average impact factor per paper (IF/Paper)	0.89 (IISc=1.89)	2.01 (IISc = 2.34)
10.	No. of US Patents granted	10	111
11.	No. of Foreign patents granted	16	179
12.	Total portfolio of Foreign patents	72	1251

Sl.No.	Subject	1995-96	2005-06
13.	Total earning from contract resources, etc.	Rs. 167 crores	Rs. 341 crores
14.	Earning from private sector	Rs. 25 crores	Rs. 94 crores (trippled up in the last three years)
15	Laboratory Reserve (based on surplus created from earnings from contract resources, which are used internally by lab (with full freedom) for extra budgetary resources)	Rs. 42.1 crores	Rs. ~ 400 crores
16.	International Honours (Cumulative): FRS US National Academy of Science US National Academy of Engineering Third World Academy of Science Fellows (TWAS) American Academy of Arts & Science Fellows	1 0 0 2 0	2 1 1 10 1
ORGANISATION			
17.	Team Spirit	Negligible. Each lab behaving as a single independent entity.	High. Hugely networked as 'Team CSIR' - also launched NMITLI - which is 'Team India'
18.	Marketing	Poor. Mashelkar Committee Report (1993) on marketing was only under consideration	Much stronger. Business Development Groups in each laboratory - proterminally managed.
19.	National & Global perception	Rather weak	High: 1. World Bank using as a model for ECA region 2. Prof.Jayant Narlikar's book

Sl.No.	Subject	1995-96	2005-06
			'Scientific edge' listing 'CSIR Transformation' as top 10 achievements of Indian S & T in the twentieth century 3. Business India Cover Story (1999) on 'CSIR Transforms -appreciation from corporate world 4. The book 'World Class in India' by Sumantra Ghoshal (Euroguru in Management) having a Chapter on CSIR (only Institution from India) for management students illustrating post liberalizational 'radical change management' in India (others are WIPRO, Infosys's, Reliance, etc.) 5. Star of Asia Award for transformation of CSIR
20.	Global firm partnerships (referring to global prestige)	Hardly any	Very strong. Partners include Proctor & Gamble, Johnson & Johnson, DuPont, Dow Chemicals, GE, Boeing, Coca Cola, Locweld, Nestle, Pepsi, Torrent, Smith Kline Beecham, Unilever, Wockhardt.

1.6 SECTOR-WISE S&T ACHIEVEMENTS

CSIR labs primarily work sectorally; in the following paras, results of a few of the more significant, both basic and applied researches, are presented sectorally. More specifically, it presents CSIR's S&T contributions in the sectors such as Aerospace Science & Engineering, Agro, Food Processing & Nutrition Technology, Biology & Biotechnology, Chemical Science & Technology, Earth System Science, Ecology & Environment, Energy: Resources & Technology, Electronics & Instrumentation, Engineering Materials, Mining/Minerals & Manufacturing Technology, Pharmaceutical, Healthcare & Drugs, Housing Road & Construction, Information: Technology, Resources & Products, Leather, Metrology, Rural Development, Water: Resources & Technology..

1.6.1 AEROSPACE SCIENCE & ENGINEERING

CSIR has been at the forefront in pushing the country's aerospace programme to new heights with path breaking research in its premier laboratory in Bangalore-the National Aerospace Laboratories (NAL). During the last decade, NAL has spearheaded the effort to design and develop small and medium-sized aircraft for the civil sector. NAL is one of the major players in supporting the national aerospace programmes of the country. It has supported Defence

R&D, ISRO, IAF, HAL and other organizations in each one of their national aerospace programmes. A number of other CSIR laboratories viz., Central Electrochemical Research Institute (CECRI), Central Glass & Ceramic Research Institute (CGCRI), Central Scientific Instruments Organization (CSIO), Central Mechanical Engineering Research Institute (CMERI), National Physical Laboratory (NPL), Regional Research Laboratory – Bhopal and Structural Engineering Research Centre (SERC) have also made significant contributions to this hi-tech sector. Some of the notable achievements are:

HANSA-3

The HANSA aircraft programme has been an unqualified success with half a dozen of these already flying, including four with the Hyderabad, Indore, Trivandrum and Karnal flying clubs. HANSA aircraft flying in the Indian skies have together notched up more than 2000 flying hours safely.

Flight mechanics and controls

Control law development for flight vehicles with special reference to unstable aircraft has been proven. A team led by NAL has developed and proved the control laws for TEJAS aircraft (LCA). All the four TEJAS aircraft are currently flying with these control laws and the laws are being upgraded continuously by using the flight test results. Control laws for trainer and naval versions of LCA are expected to be ready. LCA programme and ADA have benefited extensively by this technology.

Air Traffic Management: The R&D initiated in this area has resulted in NAL's competence being developed to a stage of practical applications. This will be an essential technology for operating future airports particularly in view of the heavy increase in air traffic in all Indian airports. Demonstration of the technology has yielded good information to plan Bangalore International Airport.

Flight vehicles / systems and wind energy systems

Micro Air Vehicles (MAV) are an area of strategic importance to the country and NAL's competence is now sufficiently mature to enable demonstration of prototypes.

NAL in association with DRDO (ADRDE, Agra) has demonstrated capability to design and build Radio Controlled (RC) Blimps. These also have many strategic applications.

Development of Wind mills of higher efficiency and endurance suited to Indian conditions is in progress.

SARAS

The aircraft had its successful maiden test flight on 29th May 2004 and the formal inaugural flight took place on 22nd August 2004. It is presently undergoing number of test flights required for Type Certification. In all 60 successful test flights have been conducted by Prototype -1 (PT1) as on 31st July, 2006 to establish basic flying qualities, stability and control aspects, handling characteristics and system functionalities. The second prototype aircraft PT2 is being equipped with higher power engines (1200 SHP). The stubwing and nacelle design are new for the PT2 aircraft because of the change of power plant. These design modifications have since been completed and the components are under fabrication. The equipping and integration of PT2 aircraft is going on at full swing and this aircraft is expected to fly in the later half of 2006. PT2 is undergoing combination endurance tests under which 200 hrs of testing has been completed. A weight optimisation design study has been initiated and it is targeted to bring the aircraft weight down by at least 400 kg. Composite structural components are being considered wherever possible. A composite empennage design has already been finalised and detailed drawings are under progress. It is planned to make a structural test specimen and a fatigue test specimen of the weight optimised structure and establish the safety margins available. These design modifications would then be incorporated in the production standard aircraft. The new power plant has been procured and a new pusher propeller has also been developed. The endurance tests on the propeller are currently under progress.

Aerospace materials

Surface Engineering and surface modification technologies including special coatings developed by NAL have benefited the Indian space programme considerably. Some special technologies of value to general engineering industry have also been successfully developed.

Development of silicon nitride balls for high temperature ball bearings has progressed and equipment for manufacture of balls for high temperature application has been commissioned at CGCRI.

NAL has developed some variants of the pressure sensitive paints and two of the paints developed have withstood 50 blow downs in the NAL high-speed wind tunnel without any performance deterioration.

State-of-the-art facilities such as Plasma Nitriding, Plasma Ion Immersion Nitriding, Failure Analysis Laboratory and Smart Materials and Shape Memory Alloys Laboratory have been commissioned and are in operation now.

High science & technology for national aerospace programmes

Work on Aerodynamic data generation on hypersonic research vehicle has been initiated and is progressing well. Initial studies on concepts like damage tolerant structures and adaptive smart structures like adaptive wing have been completed. Numerical techniques have been developed for modeling multiple damages in smart composites, addressing issues related to actuator / sensor debonding and substrate delamination. Fabrication techniques for manufacture of glass epoxy composites (flat and cylindrical) using combination of braiding and resin injection has been demonstrated. Test facilities for ramjet/scramjet combustion studies have been initiated and are nearing completion. Algorithms for on-line flight data/path reconstruction and parameter estimation, multi sensor and multi target tracking and fusion have been developed. Air Traffic Models have been simulated for Airports like Bangalore International Airport and Cochin International Airport and studies on noise contour at airports initiated. Feasibility analysis, verification and preliminary design of improved Digital Flight Data Recorder (DFDR) and design of graphical symbol generator for display system of Engine Indicator and Crew Alert System (EICAS) have been completed.

1.6.2 AGRO, FOOD PROCESSING & NUTRITION TECHNOLOGY

In this sector CSIR has in place ten institutions, namely; Central Food Technological Research Institute, Mysore (CFTRI), Central Institute of Medicinal and Aromatic Plants, Lucknow (CIMAP), Central Mechanical Engineering Research Institute, Durgapur (CMERI), Central Salt & Marine Chemicals Research Institute, Bhavnagar, (CSMCRI), Institute of Himalayan Bioresource Technology, Palampur (IHBT), Indian Institute of Chemical Technology, Hyderabad (IICT), National Botanical Research Institute, Lucknow (NBRI), Regional Research Laboratory, Jammu (RRL-Jammu), Regional Research Laboratory, Jorhat (RRL,Jt), Regional Research Laboratory,Trv.(RRL,Trivandrum), to carry out R&D of value to the sector specially agro, food processing technologies and nutrition etc. Some of the tangible achievements are:

Identification of new allergens

CFTRI has identified the allergens in pomegranate (*Punica granatum*), and cultivated mushroom (*Agaricus bisporus*), as mannitol, the sugar alcohol of D-mannose. It is the first report of IgE-mediated allergy to mannitol which is described as a new low molecular weight allergen in foods. The study has provided new insight into the mechanism of allergenicity of low molecular weight sugar alcohols. This contribution has also resulted in the development of mannitol-specific antibodies which has applicability in the development of immunoassays for mannitol.

Finger millet α-amylases degrade cereal starches and flours

CFTRI, on the basis of detailed studies, prepared various malto-oligosaccharides which can be used as fat substitutes. Ragi malt α - amylases have high specific activity and can be utilized in both bread making and brewing industries as cost-effective substitutes for barley malts.

Nutrient dense food for infants and children

CFTRI has developed weaning food for infants by incorporating amylase rich flour particularly from finger millet. A small quantity of malt flour (about 5%) could be mixed with high bulk foods prepared by popping, roller drying or extrusion cooking. By this approach their texture, nutrient density and also bioavailability of the major and minor food constituents could be improved.

Oryzanol extraction from rice bran oil soapstock

CFTRI has developed a simple and cost effective process for isolation of oryzanol. The present process works at lower temperature and for shorter duration with efficient removal of impurities for recovery of oryzanol. The process is simple and easy to scale up with reduction of number and scale of unit operations involved in the overall process

A new process for egg yolk antibodies against an insect specific protein

CFTRI has developed a process for the production of egg yolk antibodies which have high titer, consistent quality of antibody, easy to produce and non-invasive for an insect specific protein. This is very practical, economical and advantageous, as it gives high yield of antibody (165 mg of antibody/egg). The production of the titer of the antibody remains high for a longer period of time (almost 60 days), thereby providing a continuous supply of consistent quality of antibody.

Natural food colors, antioxidants from spent coffee, microbial degradation of caffeine, low grade tea

CFTRI has resolved the problem of instability to light in natural food colour by optimizing the use of antioxidants from spent coffee, which is a by product of industry manufacturing soluble coffee. The biotechnological process for degradation of caffeine uses simple substrates for the growth of the microorganisms and simple extraction procedures for the enzyme. The enzyme after immobilization and stabilization can be reused with no change in the final product. The process is safe, eco-friendly and cost effective.

Dehulled finger millet

CFTRI has developed the process of decortication of the Finger millet, wherein the texture of the endosperm of the millet is hardened by hydrothermal treatment and the grains are decorticated in a cereal milling machinery. Finger millet (*Eleusine coracana*) or *ragi* is an important nutri-cereal. The decorticated grains, with appealing light cream color resemble native grains in shape and size, cook to a soft edible texture within 5-7 min as discrete grains and contain nutrients such as protein, carbohydrates, lipids, dietary fibre, calcium and polyphenols.

Hybrid heating system for food processing

CFTRI has developed a hybrid system with provision for both convective and infrared (IR) heating of food materials for various food processing operations. This has a unique design, consists of a continuous SS perforated wire mesh conveyor on either side of which the infrared heat sources are provided for uniform heating. The combination of hot air and infrared heating reduces the overall processing time and there by increases the organoleptic quality of the product. It could be used for drying of vegetables (such as Carrot, Potato, Cabbage), and dry blanching of vegetables.

Palm oil mills of 2.5 tonnes Fresh Fruit Bunches (FFB)/hr capacity

RRL, Trivandrum has developed technology package for processing 2.5 tonnes of Fresh Fruit Bunches(FFB)/hr of Oil Palm for extraction of palm oil and is globally competitive cost-wise.

Red palmolein and zero trans shortening

RRL, Trivandrum has developed the technology package for production of carotene rich red palmolein and shortenings (vanaspati substitute) without trans fatty acids and licensed to 6 industries for commercialization. Four demonstration units of 50 tonnes/day capacity have been commissioned. The red palmolein with 500 mg/kg carotenes is an ideal and cost effective dietary approach for vitamin A supplement among children of weaker sections as vitamin deficiency is a major nutrition deficiency debilitating millions of children in India.

Physical refining of rice bran oil

RRL,Trivandrum has developed the novel technology package for effective degumming and dewaxing of crude rice bran for physical refining of rice bran oil. It has enabled commercial production of micronutrient rich (oryzanol, vitamin E and phytosterols) rice bran oil. Five demonstration units of 50 tonnes/day capacity based on this technology have been established in four states in India.

Swing technology to process fresh /dry spices for essential oils, oleoresin and active principles

RRL, Trivandrum has developed the Swing technology as a novel approach in the global context to process fresh spices to produce premium quality essential oils, oleoresin and active principles with 20-30% higher yield as compared to that of dry processing. The technology is further tailored to handle dry spices also. The technology has been licensed for commercial production to five companies. One commercial unit for processing fresh ginger based upon this technology has been established in Meghalaya.

Value-added products from crude rice bran wax

IICT has developed a simple and efficient bench-scale process for the upgradation and bleaching of crude rice bran wax to enhance its value for the benefit of vegetable oil industry. Rice bran wax (3 to 6% of crude oil) is a by-product obtained during dewaxing process of rice bran oil refining. The upgraded wax may substitute the imported carnauba wax fully or partially. The process has been transferred to one industry. IICT has also developed a process for the hydrogenated wax and transferred to one industry.

IICT has developed a bench-scale patented process for the recovery of products namely triacontanol and polycosanol from crude rice bran wax. These are presently being marketed as plant growth stimulant and cholesterol reducing agent respectively and transferred the process to three industries.

Preparation of novel phospholipids from soya lecithin

IICT has developed chemo-enzymatic processes for the preparation of various products from soya lecithin namely Acetylated lecithin, non-hydrogenated solid lecithin, hydroxylated lecithin, epoxy lecithin, Lysolecithin and Phosphatidylcholine with desired fatty acids. Lecithin and Lysolecithin are the by-products of water and enzymatic degumming processes of soybean and rice bran oil.

Enzymatic degumming of rice bran oil

IICT has developed technology package for enzymatic degumming. Enzymatic degumming step catalyses conversion of even non-hydratable phospholipids into water soluble lysophospholipids which are removed by centrifugation yielding degummed oil with very low phosphorous. This oil when subjected to refining process yields good quality rice bran oil rich in micronutrients. This enzymatic degumming process offers advantages of being environment friendly, less energy intensive and reduced water consumption. The technology has been transferred to 18 rice bran oil refineries and also licensed to 8 project engineering companies spread over 9 states.

Controlled release technology for Pest management in groundnut storage

IICT has developed a technology package comprising devices for controlled release of essential oils of reduce losses during storage of groundnut. The devices constitute all FDA and EPA approved materials like, essential oils which are plant extracts (active agents) as pest repellents loaded in natural and synthetic polymers (release agents) which are biodegradable.

A new variety of cymbopogon sps for drought prone areas

RRL, Jammu has developed a hardy drought tolerant strain CPK-F2-38 rich in citral through hybridization and rigorous screening of the F2 recombinants of *Cymbopogan pendulus* and *C.khasianus* hybrid. In the first year this variety produces 18 tonnes of fresh herb yielding about 75-90 kg of oil/ha. and in the subsequent years it produces fresh herbage yield of 20-25 tonnes yielding 100-125kg of essential oil/ha. The citral percentage ranges from 78-83 and the quality of oil has been evaluated and accepted by the user industry. The crop is perennial and lasts for five years.

Vegetable salt

CSMCRI has developed a new technology for low sodium vegetable salt which would make such salt more affordable. Sun dried *Kappaphycus* has significant quantities of salt that has been characterized to be largely KCl. This new all vegetable salt has been named as Saloni K.

CSMCRI has also developed a simple technology to obtain white, naturally free flowing salt having 85 -90% NaCl and 5-8 % KCl, 0.2 to 0.4 % Ca, 0.02 to 0.08 % Mg, 2.2 to 3.4 % SO4, 7 to 10 ppm Iodine, 1 to 2 ppm Copper, 3 to 10 ppm Iron, 0.2 to 1.0 ppm Manganese, 0.5 to 5.0 ppm Zinc, etc. The technology has been transferred to two industries.

Clone of niche pathway genes from tea

IHBT has successfully cloned genes of the pathway namely (i) Gene for dihydroflavanone reductase (DFR) (ii) Gene for phenyl alanineammonia lyase (PAL): and (iii) Gene for chalcone synthase (CHS). Catechins are important pharmaceutical compounds preventing cancer by inhibiting urokinase enzyme and are strong antioxidants. These are known to be the taste controller in tea.

Steviosides, edible bamboo and other flavouring agents

IHBT has developed important processes for production of Steviosides, Vinyl Guaicol and other flavouring agents. IHBT has also introduced varieties of edible bamboos and provided assistance in raising bamboo plantation.

Mass multiplication of bamboo in NE region

RRL Jorhat has developed a very efficient reproducible protocol for mass multiplication for important bamboo sps. viz. *Bambusa balcooa* through tissue culture technique. *In-vitro* regenerated plant showed 90% survivability. Technology for in-vitro mass multiplication of *Bambusa balcooa* has been transferred to M/s. Azara Bio Tech Company, Guwahati.

Eugenol rich cultivar of *Ocimum sanctum* 'CIM-Ayu'

CIMAP has developed the cultivar CIM-Ayu of *Ocimum sanctum,* through intensive breeding efforts, possessing high yield of biomass and essential oil with higher eugenol content. Tulsi (*Ocimum sanctum)* Family: *Lamiaceae* is known for traditional medicinal value and also the aromatic properties. It is used in a number of food preparations as well as Ayurvedic medicines and pharmaceutical preparations, due to its anti-oxidant and anti-ageing properties.

Neerkalka – a new hybrid mint plant

CIMAP has developed a new and distinct interspecific hybrid mint "Neerkalka" which is developed by sexual crossing between *Mentha arvensis* (cv Kalka) and *Mentha spicata* (cv Neera). The hybrid is propagated vegetatively by suckers or stems cuttings and is suitable for commercial cultivation.

Potato sprouting suppressant

CIMAP has developed a sprouting suppressant for potato tuber and a method for producing the same. The novel antisprouting agent comprising a mixture of essential oils obtained from aromatic plants viz. *Cymbopogon martini, C. flexuosus, C.winterianus, Mentha arvensis, Ocimum sanctum, Mentha piperita, Artemisia annua, Eucalyptus citadora, Lavendula officinalis* and *Cederus deodata* among others.

Positioning Indian utraceuticals and nutrigenomics in a global platform

This network project aims to augment nutritional deficiency of some known medicinal/ nutritional foods, such as:

Steviosides: From the tissue culture plants of *Stevia rebaudiana*, developed green processing technology for steviosides yielding about 60% of steviosides from stevia. Stevioside is known to be a sweetner 300 times more sweeter than sucrose at 0.4% sucrose concentration.

Diacyl Glycerol (DAG) rich vegetable oils: Developed nutritionally rich vegetable oils containing DAG: 25-75%, TAG: 25-40% from sunflower, soya bean and rice bran oils. These oils have balanced fatty acid profile and presence of micronutrients like oryzanol, tocopherol, phytosterols. An oil comparable to commercial product `ENOVA' oil developed.

Food grade lecithin from soybean and rice bran oil gums: Pre treatment of crude soybean & rice bran oil gums having 40-50% oil + 50-60% phospholipids was carried out to obtain food grade lecithin.

Glycolipids from rice bran and soybean oil gums: Isolated polar lipid fraction enriched with glycolipids from soya and rice bran crude gums using chromatographic technique at laboratory scale. The Glycolipid-phospholipid cocktail showed efficient transfection for breast and lung cancer cells.

ACE inhibitor: Identified an ACE inhibitor peptide from the 11S protein of soybean and transcriptome analysis of cultured human cell lines exposed to the peptide;

Nutrigenomics Database: This database aims to collect and analyse information on more than 50 parameters of nutrigenomics and till now about 750 entries have been made.

Natural, nature identical and nature similar biomolecules

Under this network project some commercially exciting results were obtained, as under: Vanilla: Genetic finger printing using RAPD and ISSC techniques has been established in different collected clones of *Vanilla planifolia*. Established shoot cultures of vanilla in liquid medium with high rate of multiplication and field testing of tissue culture vanilla plants were carried out. One year old tissue culture plant is producing flowers and three year old tissue culture plant is flowering at each node. Developed faster method for processing vanilla beans in 80 days only with enhanced flavour component as compared to traditional method of 180 days in processing.

Polyphenols from Tea: Pruned and coarse fresh tea leaves were procured and subjected to enzyme inactivation using cross flow dryer (CFD) and continuous infra red dryer (IRD) at different temperature and time intervals; green tea extract contained catechins, gallic acid. Pilot scale extraction of green tea from pruned tea leaves was completed and the fractionation for radical scavenging conserve is under progress; optimisation of the conditions for the pilot scale extraction of polyphenols from pruned/coarse tea and their evaluation.

Taxoids: Developed bench scale processing technology for the lead taxoid brevifoliol from the leaves of *Texus wallichiana*. This lead taxoid has been tested against a large number of human cancer cell lines at RRL, Jammu and it was found to have confirmed activity against oral, colon, lungs and cervix cancer cell lines comparable to taxol.

Establishing Genetically Modified Foods Referral (GMR) facility

A Genetically Modified Food Referral Facility, a state-of art facility for testing GMOs has been setup at CFTRI.

1.6.3 BIOLOGY & BIOTECHNOLOGY

This sector is served by eleven institutions; namely, the Centre for Cellular and Molecular Biology (CCMB), Central Drug Research Institute(CDRI), Central Food Technological Research Institute (CFTRI), Central Institute of Medicinal and Aromatic Plants (CIMAP), Institute of Himalayan Bioresource Technology (IHBT), Indian Institute of Chemical Biology (IICB), Institute of Microbial Technology (IMT), Institute of Genomics & Integrative Biology (IGIB), Industrial Toxicology Research Centre(ITRC), National Botanical Research Institute (NBRI), and Regional Research Laboratory, Jammu. Five other institutes namely, Central Leather Research Institute (CLRI), Central Salt & Marine Chemical Research Institute (CSMCRI), National Chemical Laboratory (NCL), National Environmental Engineering Research institute (NEERI), and National Institute of Oceanography (NIO) have also a few programmes which are specific to this sector. Some of the tangible achievements are:

Clot specific streptokinase

IMTECH has designed new-generation clot-specific proteins that display plasminogen activation property as well as two additional properties viz, time delayed kinetics of plasminogen activation *in vitro* as demonstrable by chromogenic peptide and fibrin clot dissolution assays, together with an ability to bind with human fibrin under conditions wherein natural, i.e. un-engineered streptokinase does not bind to fibrin.

A laboratory-scale process for the preparation of clot-specific streptokinase has been standardized. The Clot Specific streptokinase technology has been licenced to M/s Nostrum Pharmaceuticals Inc.,USA.

Gene silencing – A hope for cancer control

Gene silencing in plants and animals can be achieved by interfering with gene activity through the small RNA molecules, the ‘interfering RNA’ (RNAi), at specific loci during the conversion of euchromatin to heterochromatin. The disruption of RNAi interference mechanism in living cell blocks the formation and maintenance of heterochromatin, eventually leading to disruption of specific chromosome regions.The diseases involving cell division and cell proliferation, such as various types of cancers, appear to be controlled by heterochromatin formation and it's functioning. Therefore understanding the role of RNAi intervention in these processes might pave a way to use RNAi as a possible therapy for cancer and other related diseases, which involve cell cycle controls. CCMB is exploring the diverse functions of RNAi in plants, Drosophila and mammal.

Biologically derived HIV-1 protease inhibitors

NCL has isolated first biologically derived molecule ATB 1 that inhibits HIV-1 protease. The mechanism by which this inhibitor acts makes it especially robust to mutations of HIV. The isolated inhibitor has an amino acid sequence that shows no similarity to existing inhibitors, and represents an exciting new class of inhibitors with important implications for AIDS therapy. HIV requires an enzyme called HIV-1 protease in order to multiply. Thus, this enzyme is an excellent target for developing drugs against the virus.

Production of recombinant streptokinase (RSK)

IMTECH has developed and licenced to M/s Shasun Drugs and Chemicals Ltd., Chennai the technology for recombinant SK production from *E.coli* in which the yield per unit of culture-volume is several times higher than that for the natural system developed at IMTECH previously and now commercialized by Cadila. The process yields approx. 0.9 to 1.0 gram of purified rSK per litre high density culture (equivalent to ~ 60 therapeutic doses per litre of fermentation liquid). The purified rSK shows biological activity that is comparable to highest purify natural SK. The product is expected to be launched in early 2007. This technology is expected to bring down the prices of clot busters significantly and make this vital life-saver drug available to the consumer at most affordable costs.

Molecular genetics of asthma/atopy associated genes: identification of polymorphisms in *IFN* and *STAT6* genes involved in asthma pathogenesis

IGIB has carried out development of predictive medicines related to asthmatic and allergic disorders using repeat and SNPs based on the studies of population genetics and genomic data. A number of genetic and environmental factors have been implicated in the disease progression. Twenty-six single nucleotide polymorphisms (SNPs) spanning a total of 147kb region in STAT6 and IL4RA genes have been identified. Fourteen novel SNPs were found in Indian population. The proteins encoded by these two genes are part of a single signaling pathway and therefore, functional polymorphisms in these genes could potentially lead to higher risk and susceptibility to atopic disorders.

Human genome diversity

CCMB has carried out studies on a large crossection of Indian population to understand their origin, evolution and migration. Mitochondrial hypervariable region analysis of 4500 unrelated individuals belonging to 107 endogamous populations including 15 Andamanese have resulted on 72 complete mitochondrial sequences. The complete mtDNA sequences of Onges and Great Andamanese revealed novel mutational events in these two populations. The mitochondrial DNA sequences of the Onge and the Great Andamanese do not match with any other populations, including 6,500 samples covering the entire Indian subcontinent, thus indicating their origin. Novel mutations in the mtDNA of the Onge and the Great Andamanese have placed them in two unique branches in the human evolutionary tree. This study suggests that two ancient maternal lineages have evolved independently in the Andaman Islands in genetic isolation. This may be due to the initial penetration by modern humans of the northern coastal areas of Indian Ocean in their out-of-Africa migration about 50-70 thousand years ago. Analysis of Nicobarese mtDNA revealed that they belong to two lineages, which are common in China, Malaysia, Myanmar and Thailand, suggesting their recent arrival from the east in the past 18000 years.

Control of quiescence in muscle stem cells

CCMB has studying the molecular control of the quiescent state and its contribution to satellite cell function. Analysis of satellite cell quiescence *in vivo* is hampered by their rarity, while isolation from their niche invariably leads to their activation. To circumvent these difficulties, CCMB established a culture model of quiescent satellite cells using G_0 synchronized myoblasts. Studies suggest that regulation at multiple levels from chromatin modulation of transcription to regulation of cytoskeletal and membrane dynamics, and metabolic controls of nutrition, energy and cellular redox state co-operate to sustain the arrested progenitor cell, prevent precocious differentiation and maintain signal responsiveness.

Sanguinarine - Triplex DNA structures

IICB reported for the first time that sanguinarine binds more tightly to triplex structures than to duplex. It reveals that the process of binding of sanguinarine to $C.GxC^+$ triplex is exothermic and enthalpy driven while that to T.AxT triplex is endothermic and enthalpy driven. The present work on thermodynamics of sanguinarine-triplex stabilization has further supported the scope for the use of this plant alkaloid for purpose of gene regulation and gene therapy.

Identification of two candidate genes for schizophrenia and bipolar disorder

IGIB has carried out studies for Synaptogyrin 1 gene and MLC 1 gene. Chromosome 22q is one of the important regions repeatedly being implicated in schizophrenia. Synaptogyrin 1 (SYNGR1) associated with presynaptic vesicles in neuronal cells and MLC 1 gene, putative cation-channel gene, lie within 1 million base pairs of this marker, are potential candidate genes for schizophrenia (SCZ) and bipolar disorder (BPAD).

A method for the detection of predisposition to High Altitude Pulmonary Edema (HAPE).

IGIB has developed a predictive method for the detection of predisposition to high altitude pulmonary edema (HAPE). High Altitude Pulmonary Edema (HAPE) is a form of noncardiogenic pulmonary edema that develops in approximately 10% of randomly selected mountaineers within 24h after rapid ascent to altitude above 4,000 m. It particularly relates with the allelic variants of iNOS (inducible nitric oxide synthase) gene, which has been found to be related with the prevalence of HAPE.

Repetitive DNA in genome organization and function

IGIB has analyzed the distribution of (TG/CA)n ($n \geq 6$) unit repeats in human housekeeping gene on which recently released gene chip data is available. The results indicate that (i) the no. of short (TG/CA)n repeats is higher than the number of long repeats. (ii) The proportion of genes with (TG/CA) n repeats ($n \geq 12$ units) have lower mean expression levels compared to those without these repeats and (iii) The genes belonging to the functional class of signaling and communication have a positive association with repeats and the genes belonging to information class are negatively associated with the repeats. IGIB has also analyzed the role of Alu repeats in the human genome. Principal findings are: (i) The homeobox gene clusters are devoid of Alu repeats, (ii) Alu maintenance correlates strongly with functional role of genes, and (iii) Mutations in polI promoter Alus to generate polI structure.

Step towards understanding human development

In a recently published study in the journal **Cell**, a team of CCMB and IICT scientists have presented an intriguing, new and path-breaking example of how the RNAi machinery contributes to the nuclear organization with a consequence on gene expression.

Synthetic Peptide - based Nano Tubes

IICT has developed synthetic, peptide - based nanotubes that have a wide range of futuristic applications. This new class of compounds could be used for delivering DNA material for gene therapy and also making biochemical sensors. Nanotubes would help in developing a new generation of "molecular machines" and would benefit polymer, materials and electronics industries. The same group has developed modified peptide that show helicity using as few as three residues. IICT is the first to develop these unique peptides.

A novel chemoselective method for the formulation of sterols

CIMAP has developed a novel method for the formulation of secondary sterols. Vilsmeier reagent was used as an efficient form ylating agent. The reaction is simple, efficient and undergoes in mild reaction conditions to give formate esters in good yields. Other functional groups such as phenol, aldehyde, acetate and aryl methyl ether were found intact under the reaction conditions.

Production technology of biocontrol and biofertilizers

RRL, Jammu has developed standardized non-conventional process for the cultivation of selected bacterial cultures by fermentation technology for their use as Biocontrol and Biofertilizers. The process for mass cultivation of these bacteria in stirred tanks fermentors at pilot plant level has been standardized and patented. The technology for the production of viable spores of trichoderma species in the form of formulations for direct use in select crops has also been developed and standardised by RRL, Jammu. The technology for the production of biocontrol and biofertilizers has been developed at the pilot scale and demonstrated successfully to M/s Prathista Industries, Seunderabad and M/s Haryana Biotech., Gurgaon.

NBRI has developed two technologies namely *Bacillus* based and Trichoderma based microbial technology and these technology packages have been transferred to M/s Balaji Crop Care Pvt. Ltd., Hyderabad and M/s Varanasi Bioresources Pvt. Ltd. Both these technologies are biofertilizer –based technologies aimed at developing integrated approaches for enhancing the yield of plants on environment sustainable manner.

Langmuir–blodgett film based biosensor

IGIB has developed a mono-enzyme amperometric biosensor for the estimation of galactose in milk and milk products. The biosensor shows the linearity 1–4 g/dl galactose. The electrode was found stable upto 45 °C and has a shelf life of more than 90 days.

Multi enzyme based potentiometric sensor for estimation of creatinine

ITRC has developed a process for the estimation of creatinine, with the help of two enzymes immobilized in creatinine reactor followed by potentiometric estimation of urea with a urea bio-sensor. The device developed is cost effective and non-hazardous. Quantification of creatinine is possible by using it without any interference of other chemicals or ions in biological samples. It can detect upto 0.1mM in the aqueous samples.

Environmental Information System (ENVIS)

ENVIS, a decentralized system with a network of distributed subject oriented centers ensuring integration of national efforts in Environmental Information, Collection, Collation, Storage, Retrieval and Dissemination has been set-up by IICT. This centre is exclusively for information dissemination on Bioinformatics Vector Control and Vector Borne Diseases.

Biotechnological research for enzymatic products

CLRI has obtained about 18 leads for producing different proteases. The development of enzymatic process is a significant step towards materializing the paradigm shift in leather processing from chemical based to enzyme based system, whereby the leather processing becomes more eco-friendly and does not add to pollution load.

Conservation of genetic resources

RRL, Jammu has created an excellent facility in the form of a well organized gene bank which is focused on conservation for sustainable utilization of medicinal plant biodiversity of Indian Himalayan region particularly North-West Trans Himalayas using growth limitation through minimal media and low temperature storage techniques. The gene bank houses the following:

- Field gene bank repository of 300 medicinal plant species (temperature, cold arid and subtropical) created at four agriclimatic sites in North-West Himalayas.
- *In vitro* repository of 5,000 cultures of 60 accessions belonging to 40 medicinal plant species has been created.
- *In vitro* micropropagation procedure has been developed for 20 medicinal and aromatic plants.
- Genomic DNA of 88 accessions belonging to 28 medicinal plant species collected from high altidudes of North-West Himalayas was isolated, catalogued and conserved at 20 ºC.
- A **Field Gene Bank** for the rare, endemic and threatened plant species of the Indo Gangetic plains has been established in NBRI. The new field gene bank at NBRI has representative collections of over 300 plant species, including medicinal plants of the Indo- gangetic plains.

DNA marker tagged variety 'CIM-Arogya' of *artemisia annua* for high artemisinin yield

The plant *Artemisia annua* produces a sesquiterpenoid lactone endoperoxide named artemisinin, which is a promising antimalarial drug effective against *Plasmodium falciparum* and *Plasmodium vivax* at nanomolar concentration. CIMAP, has developed a novel, distinct, high herb and artemisinin yielding genotype of *Artemisia annua* through systematic marker assisted breeding followed by selection of uniform population. The genotype 'CIM-Arogya' possesses the traits of increased herb yield than the other check varieties and genotypes. CIM-Arogya produces higher biomass leading to high artemisinin yield.

Development of new tools and technologies for designing transgenic crops improved for resistance to insect pests.

NBRI has developed a number of valuable tools and approaches for designing crop varieties for resistance to field pests. Novel genes that code for two different protective δ- endotoxin proteins were designed for high level expression in plant cells. The genes were synthesized chemically and introduced into a number of plant species at NBRI. A variety of novel promoters were also developed for high level expression of such proteins.

The designing of these novel genes and promoters and the development of transgenic cotton at NBRI are the first examples of a complete Bt-cotton technology developed indigenously. The Bt-cotton lines developed at NBRI have been licensed to a number of seed companies, including M/s Swarnabharat Biotech Pvt. Ltd., Hyderabad and M/s .K. Agri Seeds Pvt. Ltd., Mumbai.

High yielding varieties in opium poppy

On the basis of multilocational performance, a high yielding variety **NBRI-10** of opium poppy has been developed following pedigree method and released for commercial cultivation. On the basis of 3 years locational trial following standard agricultural practices, the average yields have been obtained around 63 kg opium yields per hectare and 13.0 q seed yield per hectare.The morphine content in opium latex appears to be as high as 17 percent. It has recorded about 26% (opium yield), 24%(seed yield) and13% (morphine content) over national check IC-42. This variety is moderately resistant to downy mildew, tolerant to lodging and widely adoptable.

Exploration and exploitation of microbial wealth of India for novel compounds and biotransformation processes

Under this network project more than 6000 cultures from unique niches have been isolated and preserved. These are being screened for novel functions/products. 21 New taxa (genera and species) has been discovered in last four years and 10 promising leads in a new immunosuppressive, stating intermediate, new generation of taxonoids found. There are some promising leads in development of consortia for Plant growth promotion & Waste water & poultry waste. 15 Metagenomic libraries have been constructed.

Toxicogenomics of polymorphism in Indian population to industrial chemicals for development of biomarkers

Capacity and capability for undertaking studies on genomic research by microarray transcription profiling have been developed. Association of polymorphisms in ACE1 and CNOS genes with chronic obstructive pulmonary disease (OPD) has been established . A protein in human blood that is associated with arsenic exposure has been identified, and is being characterized.

Designing animals and plants as bio-reactors for proteins & other products

The project aims at metabolic engineering through genomic and biochemical strategies to manipulate the metabolite flux towards target molecules for developing speciality crops in *Catharanthus* and *Picrorrhiza*. This network project has reported cloning of native AAT gene and cecropin gene which are now ready for hyper-expression in target systems. Thermostable SOD has been cloned and is being expressed in potato likewise Gene cloned from tea and Catalase cloned from wheat. Lab-scale production of Theaflavins has been achieved using immobilized enzymes and the tea extract. Efforts for up-scaled production are underway.

Development of medicinal plant chemotypes for enhanced marker and value added compounds

Salient achievements during the period are development of process extraction, analytical quantification and large scale isolation of marker molecules of *Catharanthus, Artemisia, Bacopa, Picorrhiza, Podophyllum, Swertia, Commiphora, Acorus* and *Andrographis* is completed and a Referal SOP Manual of these methods is under preparation.

Developing cell and tissue engineering

This network programme in animal to study various cell & tissue engineering aspects of animal & plant system. For animal systems Cybrids of dendritic cells and infected macrophages, and a DNA vaccination system have been developed to obtain protective immune response in experimental animals against Leishmania; A new diagnostic system, using O-AcSG and anti-achetenin-H antibodies, for diagnosis of childhood acute lymphatic leukemia has been developed. Further cultivation of limbal cells from the human eye on novel substrates for grafting purposes in patients with damaged cornea has been done.

For Plant Systems a free cell system for induced expression of shikonins has been established for large scale production of this colorant. Also a new vector system for the anti-rabies vaccine in tobacco plant has been developed, which produces a protein that induces a protective immune response in mice.

Molecular biology of selected pathogens for developing drug targets

➲ Mycobacterium tuberculosis

Following proteins have been cloned, over expressed and purified in their biologically active form:

Enzymes: Polypeptide deformylase, alpha 1-4 glucan branching enzyme, protein kinases A and F, nucleoside diphosphate kinase A, peptidyl tRNA hydrolase, chorismate mutase, and NAD dependent DNA ligase. Virulence factors: Mycobacterial hemoglobins O and N, ESAT-6 family protein, enhanced intracellular survival protein. Crystal structure of the adenylation domain of NAD dependent DNA ligase has been determined and the structure has been used for designing inhibitors of the enzyme.Biochemical assays have been developed for mycobacterial hemoglobins, protein kinases and NAD dependent DNA ligase.Genomic expression library of M. tuberculosis constructed in E. coli.Robust DNA microarray and proteomic analysis protocols have been developed for elucidation of differentially expressed genes and proteins.

➲ Plasmodium falciparum

Choline kinase, a putative drug target has been cloned, expressed and purified. Its enzymatic properties have been elucidated and a screening assay also developed.Apicoplast DNA encoded ‘elongation factor (TufA)’ was localized to the apicoplast confirming that the parasite apicoplast is translationally active.Replication origins (ori) were identified within the apicoplast DNA and DNA protein interactions at an ori site have been identified and characterized.

➲ Leishmania donovani

Following proteins have been cloned, over expressed and purified in their biologically active form:Enzymes: Adenosine kinase, DNA topoisomerases I and II, Pteridine reductase, Trypanothione reductase.Virulence factors: Mitochondrial tRNA binding protein (component of tRNA import complex), Laminin binding protein, actin and actin binding proteins-coronin and cofilin.Biochemical assays developed for topoisomerases, Pteridine reductase and trypanothione reductase.Some natural products (dihydrobetulinic acid, luteolin, diospyrin and indolyl quinolines) identified as inhibitors of leishmanial topoisomerases.

1.6.4 CHEMICAL SCIENCE & TECHNOLOGY

The Chemical group of CSIR laboratories comprises Central Electrochemical Research Institute (CECRI), Karaikudi, Central Leather Research Institute (CLRI), Chennai, Central Salt & Marine Chemical Research Institute (CSMCRI), Bhavnagar, Indian Institute of Chemical Technology (IICT), Hyderabad, Indian Institute of Petroleum (IIP), Dehradun, National Chemical Laboratory (NCL), Pune, and Regional Research Laboratory, Jorhat. Besides these laboratories significant work in the area of chemicals is also being carried out at Central Fuel Research Institute (CFRI), Dhanbad and Regional Research Laboratory, Trivandrum. Some of the significant achievements under the sector are listed below:

Novel route to ibuprofen

NCL has developed the first heterogeneous catalysts for preparation of aryl propanoic acids. These acids are important intermediates in the synthesis of blockbuster nonsteroidal, anti-inflammatory drugs such as Ibuprofen and Naproxen.

Trifunctional catalyst

IICT has developed new immobilized catalysts stabilized in nanoclays and nanozeolites for organic transformations. A unique trifunctional catalyst anchored to silica/clay/polymer matrix has been developed to execute Heck reaction followed by asymmetric dihydroxylation (AD) and in situ oxidation of N-methyl morpholine to generate the oxidant NMO for AD in one-pot. A highly efficient "tight fit" immobilization of a-chymotrypsin in mesoporous MCM-41, with a loading of protein (w/w) wherein the effective enzyme activity 6.5% (w/w), has been achieved for the first time.

Biotransformations

Chemo-enzymatic methodologies have been developed at IICT for the preparation of 3-aryloxy-3-phenylpropyl amine, a key intermediate for antidepressant drugs and 5-(1-aminoethyl)-2-(cyclohexyl methoxy) benzamide, an important intermediate for Src-SH2 inhibitor. A one-pot lipase catalysed synthesis of enantiomerically pure secondary alcohols from carbonyl compounds and a new protocol for lipase-mediated resolution have also been developed. Efficient methods have also been developed to use lipases and phospholipases for the preparation of hydroxy and saturated fatty acid rich phospholipids from vegetable oils.

New centres for bioactives - safety and functional evaluation (biosafe) & health of pharmaceuticals - evaluation (HOPE)

IICT has established the "BIOSAFE" Centre for functional evaluation of bioactives and the "HOPE" Centre for evaluation of health of pharmaceutical preparations as per Indian Drugs and Cosmetics Act. The "BIOSAFE" Centre will cater to need of in-house as well as industry sponsored programmes associated with the development of new bioactive molecules of commercial importance and will be used for the generation of animal pharmacology and toxicology data as required by schedule 'Y' of Drugs and Cosmetics Act 1940 and Rules 1945. The "HOPE" Centre is recognized by the Andhra Pradesh State Drugs Control Administration. It will assess the quality of drugs and cosmetics employing state-of-art testing facilities. A wide range of tests in accordance with IP, BP, USP and various regulatory standards can be conducted at this centre.

Aerobic oxidation of tertiary nitrogen compounds to N-oxides

IIP has achieved for the first time oxidization of a variety of tertiary nitrogen compounds to their corresponding N-oxides in excellent yields using molecular oxygen as the sole oxidant in presence of catalyst. Oxidation of tertiary nitrogen compounds is an important synthetic transformation, as N-oxides find wide application as oxidants and offer functional group manipulation and structural modification possibilities, which are not accessible by other methods. Aerobic oxidation of other substrates is being studied to develop new oxidative synthetic methodologies.

Catalyst for deep catalytic cracking

IIP has developed a catalyst of deep catalytic cracking. It would be used for cracking of residues to maximize the production of light olefins such as propylene and isobutylene. Highly dealuminated zeolite with strong acid sites, low unit cell size has been used as one of the ingredient in catalyst recipe. Catalyst has been found suitable for high severity FCC operation for olefins maximization. The yield of gaseous hydrocarbon was found as high as 40% with higher content of C3/ C4 olefins, from heavy feedstocks. The development work was undertaken in collaboration with Centre for High Technology (CHT).

Making plastics biodegradable

An ingenious technique to convert high-volume, commonly used plastics into biodegradable materials has been developed at NCL. It is demonstrated that bacteria could be induced to degrade commodity plastics such as polyethylene, polypropylene and polystyrene. The durability of the polymers poses a grave problem as they do not degrade and remain in the environment. The increasing volumes of polymer production and consumption make this resistance to degradation a serious ecological hazard. The problem is addressed by chemically attaching a small number of sugar molecules to polystyrene. Bacteria readily attack the sugar molecules (sucrose, glucose, or lactose) and, in the process, they seem to break up the otherwise-resistant polystyrene. As little as a few percent of sugar incorporated onto the polystyrene chain dramatically increases the rates of polymer degradation, while leaving other desirable properties of the polymer substantially unchanged. This novel method represents a significant improvement over previous attempts. Further work in this regard was in progress.

Biomimetic approach to nano-particles for diagnostics and therapeutic use

Studies at NML have demonstrated the self-assembly of highly oriented array of SPM iron oxide particles that are biomimetically precipitated in protein and synthetic polymeric matrices under the influence of an external magnetic field. The role of biomimetic synthesis in synthesizing mono-disperse hydroxy-apatite particles as well as polymer hydroxyapatite composites for various applications in orthopaedic treatment was demonstrated. The work contributes towards the understanding of micromolecular interactions with selective cations leading not only to controlled nucleation and growth but also their self-assembly to form long range structures with and without an external stimuli like magnetic field. The studies also demonstrate that how an external field leads to the selective nucleation of a specific polymorph as a result of reduced entropy of the system. Based on the above results it is planned to go for the clinical trials with superparamagnetic iron oxide and hydrooxyapatite particles.

Three-component reactions under thermal and microwave irradiation

The indolizines and dihydropyrimidinones are synthesized in a one-pot reaction via three component reactions (3-CR) in excellent yields. Dihydropyrimidinones have emerged as backbone of several calcium channel blockers (nifedipine), anti-hypertensive agents and marine derived alkaloids having HIV inhibitor activities. A fast solid phase synthesis of 1,5-diketones via Michaeal addition was achieved and employed at RRL, Jorhat for synthesis of a novel class of 1',2'-diazepino[17,16-d'] steroids. The contribution made in these studies have established the viability of a three component reaction (3-CR) involving a 1,3-dipolar cycloaddition reaction between an in situ generated dipole using microwave energy and a Biginelli condensation using metal catalyst. The strategies provide the first successful example of the application of this approach and an access to fast one-pot synthesis of indolizines and dihydropyrimidinones which otherwise are accessible only through multi-step synthesis. The methodologies denote a new class of 3-CR and an advancement of Biginelli condensation reaction, which are expected to be general routes for the facile, one-pot combinatorial synthesis of a wide range of indolizines and dihydropyrimidinones.

Conductive hydrogel

CECRI has developed a conductive hydrogel. It is a component of disposable ECG electrode and provides ready adhesion for measurements in diagnostic tools. This biologically acceptable polymer is cost effective has a long shelf life and is resourced from a cheaper source. It is unique as the conductive gel could be converted into a laminate, sheet or film meeting the device configuration.

Gold plating on aluminium alloy components

The cover plates of momentum Wheel Assembly and Reaction Wheel Assembly used in INSAT and IRS satellites are made of AA 6351 Aluminium alloy. These components are to be plated with gold as per ISRO specifications. A plating facility for carrying out this work was set up at CECRI and gold plating of IISU components was in progress. Feasibility study regarding gold plating on AA 6351 and AA 2024 alloys was taken up initially for IISU, Thiruvananthapuram. After successful development of plating procedure, the components were plated and sent to IISU for testing. The quality of plating was found to be satisfactory for space applications as per ISRO specifications. Based on this a gold plating facility has been set up at CECRI to carry out plating to the requirements of IISU.

Scratch resistant coating on plastic by sol-gel processing

A process has been developed at CGCRI for making abrasion resistant coatings on polycarbonate sheets and ophthalmic lenses based on UV curable inorganic – organic hybrids (epoxy methacrylate – silica) loaded with boehemite nanoparticles. The method has also been used for depositing inorganic-organic hybrid coatings doped with gold and silver nanoclusters respectively on polycarbonate substrates for application as abrasion-resistant coloured coatings and nonlinear optical materials.

Novel adsorbent for oxygen, nitrogen and argon separation from air

A novel zeolite based adsorbent for separation of oxygen, nitrogen and argon from air has been developed at CSMCRI. Some of the commercially significant features of the adsorbent are: high adsorption capacity for N_2 almost 1.5 times compared to the best capacity values reported for similar zeolites; and high selectivity for nitrogen from its mixture with oxygen compared to reported selectivity of 3-4 for similar zeolite. It is the first zeolite based adsorbent showing selectivity for N_2 as well as Ar over O_2. A PCT application has been filed for the development which offers a new technique of developing adsorbent by cluster formation inside zeolite cavities.

Biopigment: production C-Phycocyanin

CSMCRI has developed a process for production of high value fluorescent pigment, C-Phycocyanin (C-PC), from a strain of *Spirulina platensis*. The absorption spectral data show, that the CSMCRI product has similar absorbance at 620 nm as the product from Sigma, when both spectra are recorded with similar concentrations of C-PC (0.14 mg/ml).

Precipitated Calcium Carbonate (PCC)

CSMCRI has developed a process for production of Precipitated Calcium Carbonate (PCC) from calcium carbonate rich by-product of nitrophosphate plant. The product obtained is rubber, PVC, paint and toothpaste grade. The unique features of the process are that it produces calcium carbonate from inorganic powder having average particle size of 50 micron, and an alternate raw material to natural lime stone for producing PCC is established. The knowhow has been transferred to a fertilizer industry. The development will be useful to all the fertilizer industries having nitrophosphate plants where the problem of disposal of inorganic byproduct is faced.

Low sodium salt from bitterns

The intake of low sodium salt in place of pure sodium chloride is being recommended to patients suffering from hypertension. Presently no technology exists for the production of low sodium salt directly from brines. CSMCRI has developed a process for the recovery of low sodium salt (a mixture of sodium chloride and potassium chloride) from bitterns, byproduct of salt industry.

Chirally-pure anti-hypertensive drug: (S)-Amlodipine

Asomex-2.5, the first chirally pure anti-hypertensive drug launched on the Indian market has been manufactured by using a patented technology developed at NCL. Amlodipine, the molecule on which Asomex-2.5 is based is chiral, viz. it has "handed-ness". The NCL process uses a cheap and naturally occurring resolving agent to separate out (S)-Amlodipine with a chemical and optical purity exceeding 99.5%. This is a significant improvement over the Pfizer process that uses costly and unnatural D-tartaric acid for resolution. Asomex-2.5 has been used in clinical trials. The chirally pure (S)-Amlodipine does not lead to any of the adverse side effects observed for treatment with the racemic mixture. In addition, Asomex-2.5 has been observed to lower the patient's LDL cholesterol level.

NTGG process – a commercial success

IIP has developed a process for conversion of Naphtha to Gas and Gasoline (NTGG) The process is based on a novel zeolite catalyst, which selectively converts the C5-C6 rich feed stocks to LPG and high octane and low benzene gasoline with very low dry gas yield. The catalyst and the process were developed with Gas Authority of India Ltd. (GAIL). IIP prepared the basic engineering package, based on which GAIL started the detailed engineering and construction activities in June 2000 for setting up demonstration unit at Vaghodia, Gujarat. The plant has been successfully commissioned this year. On-spec LPG and gasoline was produced in the first run itself in a record time of under four hours. The Vaghodia unit has demonstrated the technology successfully and valuable data is being collected for its further scale up and development. A US patent has been granted and four patents are filed in India on NTGG and related processes by IIP.

Pressure Swing Adsorption (PSA) process for helium

IIP has developed a process for the recovery of Helium from low helium bearing gas mixtures such as natural gas. Helium is present in small amounts in some of the natural gases, found in Rajasthan area, in gas emanations from thermal springs in West Bengal and in off gases from monazite sands processing operations in Kerala. The PSA technology developed is a step towards indigenous capability development for extraction of this strategically important material. The process involves a two stage PSA operating at ambient temperatures and uses commercially available adsorbents. The process is able to enrich helium from concentration levels of around 4 mol% to around 85 mol% with a recovery of 75%. The two stage PSA uses different cycles in each stage designed to maximize helium purity and recovery. The process is being scaled up.

Biosynthesis of nanoparticles using fungi

The controlled synthesis of nanoparticles over a range of sizes and chemical compositions has emerged as an extremely important area of nanotechnology. Inspired by the exquisite inorganic nano-scale structures generated by micro-organisms of NCL has demonstrated the synthesis of silver and gold nanoparticles of good monodispersity within the cells of a fungus, *Verticillium.* It is found that treatment of the fungal biomass with aqueous ions of gold chloride ($AuCl_4^-$) resulted in reduction of the metal ions and intra-cellular formation of gold nanoparticles. The formation of gold nanoparticles is visible to the eye in terms of the biomass turning purple in color. Thin section TEM analysis of the *Verticillium* cells showed that the particles were fairly monodisperse and bound to both the cell wall and the cytoplasmic membrane. It is believed that reduction of the metal ions is due to reductases present on the fungal cell wall/on the cytoplasmic membrane.

Green route to antidepressants

NCL has developed a high-yield route to a new generation antidepressant, Venlafaxine. The novel process uses mild reaction conditions; substitutes hazardous reagents with cheap, relatively non-hazardous chemicals and; the key step is performed in water rather than in an eco-unfriendly organic solvent. The NCL process is a four-step reaction that employs two novel patented schemes. This process introduces significant improvements in the first two steps over what is currently practiced.

2-Methlyallyl sulfonic acid sodium salt and 2-acrylamido-2-methyl-1-propane sulfonic acid

These are speciality monomers that find applications in the acrylic fiber industry for imparting dye-affinity to the fiber. Polymers prepared by using later monomer (ATBS) are also extensively used in the Enhanced Oil Recovery (EOR). Similarly it is used in water treatment chemical and in preparation of specialty polymers. M/s Vinati Organics Limited (VOL), Mumbai, sponsored the project to NCL for development and transfer of the technology for these two monomers. NCL successfully developed the process for both the monomers. It was successfully demonstrated to VOL on the bench scale as well as on the pilot scale.

Preparation of alumina membrane for micro and ultra - filtration

NML has designed and prepared a very thin disc type ceramic membrane (0.3-0.8 mm thickness, 25-30 mm diameter) made of pure alumina. It is suitable for micro-filtration applications. A very sharp drop in the pore size distribution pattern around 0.4 μm indicates that no pores larger than this exist. This implies that all particles with radius > 0.4 μm are trapped in the membrane, providing excellent separation efficiency. Results of microbial separation tests confirmed the possibility of micro-organism separation through these membranes.

Fabrication of *in-situ* dense Al_2O_3-ZrB_2 and Al_2O_3-ZrB_2-TiB_2 composite

NML has achieved the fabrication of *in-situ* Al_2O_3-ZrB_2 and Al_2O_3-ZrB_2-TiB_2 composite by SHS dynamic compaction technique. The process developed for making such *in-situ* composite uses cheaper raw materials such as oxides of the components and one of the constituent as metal powder. A range of composites based on alumina with zirconium diboride and titanium diboride at different volume percent could be manufactured through the process.

Extraction of natural dyes from the plant sources

RRL, Jorhat has isolated pigments from *Morinda angustifolia* and established its chemical structure. It is amorindone type of compound containing an anthaquinone group. The dyeing properties of the pigment have been evaluated. Silk and cotton fabrics can be dyed with this colour component with and without using different mordants to obtain a wide range of colours with fair to good wash and light fastness. Thus, the dye so extracted could be an alternative to synthetic dye for dyeing of silk and cotton.

Microwave induced process for the preparation of substituted 4-vinyl phenols

A new microwave induced process has been developed by IHBT for the synthesis of substituted 4-vinyl phenols. 4-vinyl phenols (No.3739) and 4-vinyl guacos (no. 2675) are FEMA approved flavoring agent which are known for spicy, apple, rum roasted and clove like flavors. Synthetic preparation methods are tedious. Microwave assisted method is a rapid and economical process and results in development of a highly purified product in large quantities.

Synthesis of carbohydrate dendrimers

This work at IICB describes an expedient approach to internally functionalised chiral dendrimers incorporating furanoside skeletons. A dendrimer incorporating pentose units in the interior and hexose units in the periphery is built up on a 1, 3, 5-trisubstituted aromatic core by using 1,2,5,6-di-isopropylidene glucose as the carbohydrate precursor and a 3, 5-disubstituted aromatic unit as the branching block. The carbohydrate moiety also provides internal functionalities in the form of hemiacetal moiety of the furanoside ring. The contribution will make possible the synthesis of carbohydrate dendrimers, which could be functionalised and coupled through conjugation to biologically important molecules such as peptides leading to the development of materials with novel biological properties.

Novel Ni(II) mixed ligand complex modified electrode: catalytic effect on anodic oxidation of phenol

ITRC has synthesized and characterized Ni(II) –cyclame thiocyanate complex and for using it as a carbon paste electrode modifier for oxidative detection of phenol. The electroactive mixed ligand complex behaves as a fast electron mediator and exhibits reversible redox peaks. The mixed ligand complex of nickel, when incorporated in the graphite paste electrode, is sensitive to detect phenol as low as 10 ppb in solution. The technique has the potential for sensing/monitoring of phenol released in the ecosystem from polluting industries. This knowledge can be applied for developing technology for detection of other phenolic compounds.

Single step preparation of p-Aminophenol- an intermediate for paracetamol

p-Aminophenol is an intermediate for making paracetamol, a widely used antipyretic and analgesic drug. Conventional method of preparation of paminophenol involves Fe/HCI reduction of p-nitrophenol, which poses a serious effluent problem, due to generation of large amount of Fe-FeO sludge. NCL has developed a non-corrosive solid acid catalyst and a bench scale process for preparation of p-aminophenol.

Under the process optimization work the p-aminophenol selectivity has been enhanced from 58 to 70 per cent by pretreatment of the catalyst and modifying the work up procedure. A successful bench scale demonstration is given (2 liter and 300 ml scales) to the sponsor. Based on the NCL bench scale process, a Basic Engineering Package (BEP) for pilot plant (100 liter vol. reactor) has been prepared and given to the client.

Conversion of flyash into eco-friendly catalysts

Flyash, a by-product of coal burning, contains mostly aluminosilicates. NCL has developed a process to convert environmentally detrimental flyash into a crystalline and pure zeolite beta, an industrially important catalyst.

Development of catalysis and catalysts

Under this network project some commercially exciting results were obtained, as under:

Silica based mesoporous materials:

- The know-how of (Ti-silicate, ZSM-5, KL and Beta) has been successfully transferred to an Indian company (Vamshi Exports Ltd., Mumbai). Know How fees charged was Rs. 25 lakhs. This excluded future royalty. The scale-up and optimization of three mesoporous materials (MCM-41, MCM-48) is under way and the same company has shown keen interest in the production of these mesoporous materials and in all probability the know-how for these materials will be transferred to this Indian and possibly to some other catalyst manufacturer. The work on developing scalable recipes and subsequent scale-up of these mesoporous materials (at least MCM-41) is expected to be completed by March 2007;
- MCM-41& 48 were prepared from various silica sources. Various metal containing catalysts are prepared at lab scale under different solvent and hydrothermal conditions. Encapsulation and stabilization of gold nano-particles in mesoporous solids was carried out.
- Carbon based mesoprous materials were synthesized using silica based mesoporous materials as template. These materials are being tested for VOC removal.

Methane coupling

Preparation, characterization and catalytic screening of different catalyst based on zeolite, pillard clays, salts of heteropoly acids, and promoted metal oxides for methane to ethylene conversion.

Development of novel polymeric materials

The achievements reported under this network programme are :

- UV/E beam curable coating

NCL has standardised a process for facile synthesis of terpolymer of poly(hydroxy styrene). Formulation based on this base resin was tested which could resolve 1 micron geometry. The material has potential for I line and deep UV. Photoresist of 1.4 mm thickness with good sensitivity and reproducibility was established. It is also demonstrated that `high *ortho*' novolac copolymers with optimum *m*- and *p*-cresol content and optimum base solubility has yielded a well-defined line latitudes and excellent performance against conventional lithographic steps like etching, lift-off and others. The photoresist is currently under test at semi commercial level at SSPL, New Delhi.

- Functional polymers for chiral separations
- Tailored beaded hydrophobic polymer matrices for the immobilisation have been developed as polymeric supports.
- Electroactive/ conducting polymers for applications in electronics Industry

A new route for synthesis of polyaniline by non-acidic method has been achieved which gives non-corrosive, environmentally friendly method for large-scale synthesis of this material. Also, the processability of the conducting polyaniline has been achieved by introducing a dispersing agent, which also acts as a processing aid. These compositions can be injection moulded, extruded or compression moulded into various shapes.

Developing green technologies for organic chemicals

- Extraction/isolation/ scale up of artemesinin upto 5Kg batch.
- Laboratory scale synthesis of pheromone components IV (E11-hexadecene-1-ol) and V (E11-hexadecenyl acetate) up to 25g batch.
- Synthesis and up-scaling of the process technology for pheromone components I(Z11-hexadecen-1-ol), II(Z11-hexadecenal) and III (Z11-hexadecenyl acetate) upto 25 g batch size
- Production of Polylactic acid (PLA) from Biomass
- Production of Gamma Linolenic Acid from Agro Products
- Modified zeolite catalysts for alkylation of naphthalene with methanol
- Oxidation of p-xylene to terephthalic acid in aqueous phase
- Development and demonstration of process for Trifluoroethanol
- Chemical route: Development and demonstration of process for Heptafluoropropane (FM200)
- Electro chemical route : Upscaling of pPerfluoroisobutyric acid by Electro Chemical Fluorination upto 5Kg batch
- Development and demonstration of process for 1,1,1-trifluoro-2,2-dichloroethane (HFCFC-123)
- Development of an improved process for preparation of HCFC-123 from CFC-113a
- Production of sodium silicate, a detergent grade zeolite.

Globally competitive chemicals processes and products

- Development of process for xanthophyll dye from T erecta flowers.
- Scale up of preparation of Dipotassium Rhodizonate, Dipotassium Croconate, Barium Croconate, Croconic acid upto gram level for synthesis of NIR dyes.
- Upscaling and demonstration of Taxol side chain and Diltiazem using the supported catalysts
- Development of Titanium oxide electrodes from chemical grade TiO_2
- Preparation and demonstration of Aluminum phosphate catalysts and Aluminum zirconium phosphate for dehydration of methanol to DME.
- Preparation and upscaling of Isonicotinamide and INH to 50g and 100g batch.
- Development of new catalyst systems Cr-terephthalate mesoporous materials for direct hydroxylation of benzene

1.6.5 EARTH SYSTEM SCIENCE

Two CSIR laboratories, National Geophysical Research Institute (NGRI), Hyderabad and National Institute of Oceanography (NIO), Goa are exclusively devoted to R&D for earth resources besides other laboratories viz. CBRI, CRRI, SERC-M have expertise and facilities to contribute on specific aspects of activities on Natural Hazards Assessment. Some of the achievements are:

Fundamental understanding of Indian lithosphere

- The Indian peninsular shield is a mosaic of several geological provinces. The Precambrian South Granulite Terrain (SGT) which represents lower crustal rocks were studied along a 500 km N-S corridor along Kuppam to Kanyakumari using geological, geophysical, geochemical and geochronological tools. The results from multi-disciplinary inputs show two major tectono-metamorphic cycles culminating at 2.5 Ga and 0.55 Ga during the complex evolution of the SGT.

- Convincing evidences for Neo-Proterozoic transpressional tectonics related to continent-continent type collision both in the Eastern-Ghats Granulite Terrain and Southern Granulite Terrain are also obtained. The far-reaching implications of these studies, to the evolution of earth's lower continental crust were published as a special memoir of the Geological Society of India and also in several National and International journals.
- Mantle heat flow and corresponding thermal model for the northern block of the Southern Granulite Terrain (SGT) was obtained by integrating heat flow and radiogenic heat generation data with crustal structure obtained under the Kuppam – Palani geo-transect programme. The results suggest normal mantle heat flow in this part of the Indian shield generally considered as deep-section of an ancient orogenic belt.
- A major contribution has been in terms of preparation of revised 'Free-air' and 'Bouguer Gravity Anomaly' maps on 1: 2 million scale by merging the GSI and NGRI gravity data sampled at a 3 minute arc interval. Further, satellite-based gravity studies provided free-air gravity data of the offshore region for better understanding of the continental margins of India.
- Magneto-telluric studies in the Puga valley of Jammu & Kashmir suggest the possibility of an anomalous geothermal reservoir of 4 to 5 km thickness at a depth of 1.5 km.
- NGRI IGS GPS Permanent Station's data was used during the collaborative work with University of Miami, USA and has resulted in the new Global Plate Motion Model named as REVEL-2000, which includes the recent velocities of many new sites that have emerged globally in most of the plates.
- Continuous GPS monitoring between India and Antarctica provided precise estimates of the crustal deformation between these two landmasses. A Website giving on-line description of GPS campaigns and Maitri station in Antarctica has been made available. Further, from the time series of Hyderabad IGS station baseline lengths between Hyderabad and Seychelles and Coco was found to be shortening at the rates of 2.7 cm/y and 5.2 cm/y, respectively, which very clearly conforms to the estimated IGS GPS global velocities.
- An algorithm has been developed for anisotropy velocity analysis for multi-layered flat horizontal earth and the same has been coded in terms of Fortran-77 program and submitted for Patenting and copyright.

Seismic hazard and natural disasters

- A site-specific seismic hazard microzonation map of the Jabalpur urban area has been prepared using a multi-disciplinary approach involving geological, geotechnical, seismological, geomorphological and vulnerability studies. Considering a maximum credible earthquake of Mw 6.5 a base value of seismic hazard was estimated using a deterministic approach. It is found that PGA for base rock in Jabalpur domain varies from 0.11g in proximity to causative fault trace to 0.09g in the farthest northwestern part of the study area. The Jabalpur area is characterized by 13 types of response curves. The domain is further classified into 9 frequency units. The amplification, in general, varies from < 1 to 8.
- A seismic hazard map of India and adjoining regions was prepared.
- The 26 December 2004 Sumatra–Andaman earthquake (Mw 9.3) was the most devestating earthquake of the modern seismological era. The rupture characteristics of the earthquake, particularly in the Andaman–Nicobar region, are not well resolved from seismological or far-field geodetic data. NGRI estimated coseismic displacements from campaign mode Global Positioning System (GPS) measurements at 13 sites in the

Andaman–Nicobar Islands and several far-field permanent GPS sites before and after the 2004 Sumatra–Andaman earthquake. These measurements provide improved estimates of rupture characteristics in the region. Co-seismic horizontal ground displacement of 1.5–6.5 m towards the southwest and co-seismic vertical displacement, mostly subsidence, of 0.5–2.8 m occurred along the Andaman–Nicobar Islands with maximum displacements in the Nicobar Islands. In India, the permanent GPS sites at Hyderabad and Bangalore showed co-seismic horizontal displacement of 6-11 mm towards east. Co-seismic slip under the Andaman and Nicobar Islands is estimated as 3.8–7.9 m and 11–15 m, respectively. The length of the rupture is estimated to be about 1500 km with a width varying from 120 km under Middle Andaman Island to 160 km under Great Nicobar Island. The similar exercise for the 28 March 2005 earthquake (Mw 8.6) were performed. The earthquake caused co-seismic displacements of up to 4.5 m. The rupture of this earthquake mostly occurred under the island belt and hence it could not displace a large amount of water to cause a major tsunami. GPS measurements after the great earthquake of 26 December 2004 suggest that intense deformation is occurring in the region and suggest rapid after-slip in the down dip part of subduction interface that lies further down dip of the ruptured part of the subduction interface. Limited GPS data available from 1995 measurements at two sites in Andaman provide evidence of strain accumulation that varied significantly in the 10 yr preceding the earthquake. Measurements of these displacements at continuous and campaign mode sites in the rupture zone area will provide constraints on rheology of the subsurface material and estimates of recurrence interval of large earthquakes in the region.

- A systematic tsunami run-up survey along the 350 km Tamil Nadu coast, after the 26 December 2004 Indian Ocean tsunami brought out several important factors for mitigating the tsunami hazard along Indian coastlines. The studies revealed that i) the tsunami run-up heights along the east coast of India in Tamil Nadu varied between 2.5 to 5.2 meters, ii) most of the loss of life and damage to property was in the first 100 meters from the shore where several settlements were washed away, iii) small differences in local run-up and coastal topography resulted in large differences in tsunami inundation and associated loss of life and damage within the Tamil Nadu coastal areas, iv) the combination of local high run-up, low topography and dense development apparently accounted for the large loss of lives and property. The surge water elevations, together with surge water depths appear to be important parameters in tsunami hazard analysis and v) low valleys behind shore-parallel dune ridges claimed several lives due to lateral flows from tidal inlets or from breaches in the dune ridge.
- The concept of Nucleation provided the first positive indications for developing a model for earthquake forecasting in the Koyna region in India. This concept was granted a US Patent in 2004 on "Method of short term forecasting of moderate size earthquakes. Later, two successful predictions were made for moderate earthquake in the Koyna region based on nucleation and reservoir water levels.
- For the first time a systematic study for hydrological precursors in the Koyna region provided clues to co-seismic changes in well water level fluctuations. These results are very encouraging to look of pre-seismic signals in the data to develop earthquake forecasting models for the region

National exploration programme

- A Major sedimentary basin with 2.5-3.0 km thickness Mesozoic sediments, a potential source for hydrocarbons, was delineated between Narmada-Tapti region of Deccan Syneclise around Shirpur, Saver and Sendhwa has been inferred on the basis of Controlled Source Seismic (CSS) magento-tellurics, gravity and deep resistivity studies.

- The Mahanadi delta was modeled through seismic (controlled source seismology using 240-channel RFT) and gravity methods, which led to the delineation of structures favourable for hydrocarbon prospects in the Cuttack depression.
- Magnetotelluric methodology has proved its preeminence for volcanic rock covered regions over other geophysical methods. This has been proved earlier in Saurashtra and also in Kutch regions of Gujarat in India. Based on this methodology, a sediment thickness map for western India covering parts of Narmada-Cambay basins was prepared. This map has been used by the Directorate of Hydrocarbons, New Delhi, to demarcate the area for bidding under NELP rounds to exploit the area for production of hydrocarbons.
- A permanent state-of-the-art seismic station has been established at Antarctica, which was later upgraded to a digital system few years back and a GPS station at Antarctica. These are two major landmarks of Indian Antarctic scientific effort and are globally appreciated.

Ocean related

- Evaluation of physical and biogeochemical processes regulating oxygen minimum zones of the Arabian Sea and the Bay of Bengal - Monthly mesopelagic oxygen budgets for the two basins constructed from Modular Ocean Model. Dominance of monsoon related physical supply of oxygen as well as consumption processes established for both basins.
- Comprehensive carbon budget for the Arabian Sea worked out using multi-disciplinary data sets generated during the JGOFS.
- The mechanism that retains nodules at the seafloor also seems to be operative on the tektites, thus leading to this apparent “age paradox” of tektite/microtektite distribution in the Indian Ocean, although they both belong to the same impact event.
- Formation of nitro-PAH compounds was found in fish contaminated with PAH and exposed to nitrite (NO_2^-) in the ambient water. Nearly 92% of the hepatic cells of the fish exposed to phenanthrene in the presence of NO_2^- were found to have suffered extensive DNA fragmentation on comet assay.
- High-resolution paleo seasonal sea surface temperatures were reconstructed that show a strong seasonal SST contrast between winter and summer during the last glacial period as compared to the Holocene
- Long-term time series currents and temperature data from 6 depths from the eastern equatorial Indian Ocean (EEIO) were generated. The time series currents showed the presence of intra-seasonal variability (ISV) with 10-20 day and 40-50 day periods and low-frequency semi-annual variability.
- A new technique, with algorithms based on statistical relationships for tropical Indian Ocean making use of satellite derived Outgoing Longwave Radiation (OLR) and an ocean parameter, the Effective Oceanic Layer (EOL), was applied to the Bay of Bengal to estimate sea surface salinity from remote sensing data.
- The measured excess ^{210}Pb inventories (124–211 dpm cm^{-2}) for the sea floor sediments below the Western Arabian Sea Trap and from other locations in the vicinity of the sediment trap mooring lend support to boundary scavenging within the northwestern Arabian Sea as a sink for ^{210}Pb.
- A new species of thraustochytrid isolated from mangroves of Goa, India, which is named as *Thraustochytrium gaertnerium*. The organism is characterized by large zoosporangia with two distinct development cycles. The two types of development occur simultaneously in single cell-derived in- vitro cultures.
- First gas hydrate sample (contain pure form of methane gas) was obtained in KG offshore from Deep sea drilling, which confirmed the presence of >80m thick gas hydrates zone

below the seabed (JOIDES Resolution, NGHP Gas hydrate cruise). Tentative estimates indicate the presence of several billion cubic feet of methane.

- Mineral chromite ($FeOCr_2O_3$) is discovered as a placer mineral for the first time in India along Malvan Coast Maharashtra. Onshore Exploration along S.Maharashtra has indicated 1.02 million tones of heavy minerals of which the ilmenite (with 38-51% TiO_2) and chromite (with Cr_2O_3 26-50%) are of medium grade

Modelling

- The Modular Ocean Model has been installed and evaluated; this paves the way for ocean state forecasting.
- The Neural Network model for long-range forecasting of monsoon rainfall has been successfully used to generate experimental forecasts for the past seven years.
- Development of the first Version of the Parallelized GCM
- Validation and Verification of the Various Finite Elements Available in FINEART development and refinement of a number of theoretical and conceptual issues in the areas of finite element analysis, elastodynamics, numerical algorithms and non-linear dynamics.

Atmospheric science

- A new procedure has been developed to estimate more precisely the Faraday Rotation correction to be applied in the sea surface measurements using satellite borne radiometers. This is in use by ISRO satellites.
- First ever simultaneous multi-parameter measurements of fog at a station in Delhi revealed an additional boundary layer close to the ground that plays significant role in influencing fog processes.
- Studies on aerosol, trace gases and UV solar radiation characteristics over Arabian Sea and Indian Ocean in October-November 2004 showed significantly different results from those found during the INDOEX.
- A major inter-comparison campaign involving around 60 instruments from twenty institutions, that were deployed at the six sites across the Indo-Gangetic plains region for a month long observations, as a part of ISRO organized National Aerosol Land Campaigns program.
- In Antarctica, measurements of columnar ozone, water vapour, methane and carbon monoxide etc were pursued. Weakening of the ozone hole strength, compared to earlier years, because of the altered meteorological and dynamical conditions was found over the Antarctica.
- Operational support was extended for agricultural experiments at IARI to study the response of crops grown under the CO_2 enriched ambient air using the in house designed and fabricated FACE facility. The facility is available to Asian scientists.
- Installation and commissioning of a VSAT Network [WAN] for On-line monitoring of the seismicity of NE India, real-time location and computing of data to study the precursory phenomenon.
- Major Tectonic lineaments in NE India have been delineated
- The present trend and rate of seismicity have been identified to define the source zones
- Suitable algorithm has been developed for waveform modeling and source characterization
- Expertise has been gained to evaluate site amplification behaviors for use in seismic microzonation

Development of techniques and methodologies for exploration, assessment and management of ground water in hard rock areas

Integration of geo-information combined with geo-electrical imaging has been found successful to delineate potential groundwater zone in granitic terrain. Various thematic maps have been prepared to decipher aquifer zones in basaltic terrain and it formed basis for various other studies such as recharge experiments, geophysical investigations and hydrogeological investigations. Applications of MASW and GPR have been made to delineate potential groundwater zones in basaltic terrain. Natural recharge rate evaluated through the application of injected tracer, carbon^{14} and chloride in Wailapalli and Ghatiya watersheds. Hot spots in basaltic terrains have been delineated. Soil, surface and groundwater samples from alluvial area (Unnao) have been analyzed for physio-chemical parameters, heavy metal, pesticides and polycyclic aromatic hydrocarbons. Geochemical maps showing the distribution of fluoride, uranium and thorium have been prepared which show very high concentrations of these in rocks and soil samples of Wailapalli. In order to augment fluoride free potable water, Resource-cum-Recharge well and a Capture well have been developed. In tank well has also been set up to augment groundwater in basaltic terrain. Automated Multi-electrode SP recording equipment has been developed and lab testing carried out. The total groundwater draft and aquifer geometry on island have been arrived. Interpretation of geophysical investigations has been carried out to delineate aquifer zones on another island. RO plant with reject water management has been developed in lab to filter fluoride with a provision to precipitate F and dispose it safely.

Study of mesozoic sediments for hydrocarbon exploration

The presence of sub-trappean Mesozoic sediments has been established in Saurashtra and Kutch using integrated geophysical studies in encompassing seismic refraction, magneto-telluric, deep resistivity sounding and gravity. The know-how developed is unique and would go a long way in reducing the risk involved in hydrocarbon exploration in such complex areas. As different techniques are used to map sub-trappean sediments, the methodology is extremely reliable and can be applied in other areas.

Tectonic and oceanic processes along Indian ridge system and back arc basins

Swath bathymetric mapping and sampling of Carlsberg and Central Indian Ridge segments seabed sampling and CTD observations, were carried out. Multi-parameter data (geophysical, water column (phys, chem. & bio) and seabed samples acquired. Preliminary processing of the data completed. Extraction of Helium from water samples and analysis for $^{3}He/^{4}He$ ratio, attempted for the first time. Specifically collected samples from SK-201 and SK-207 were analysed for Helium. Integration of physical, chemical and biological parameters of the water column with tectonic features.

Acquisition of Oceanographic Research Vessel (ORV)

Vessel dimensions have been finalized. Consultant selected, Conceptual design completed, Model tests were carried out. Bid document for yard selection finalized and tender floated.

1.6.6 ECOLOGY & ENVIRONMENT

CSIR provides in a major way S&T support to evolve national policies and to ameliorate environmental problems. CSIR laboratory, National Environmental Engineering Research Institute (NEERI), Nagpur is devoted to this sectors. Other laboratories, viz, Central Leather Research Institute (CLRI), Chennai, Central Salt & Marine Research Institute (CSMCRI), Bhavanagar, National Institute of Oceanography (NIO), Goa, Industrial Toxicology Research Centre (ITRC), Lucknow, and Regional research Laboratory (RRL), Bhopal have expertise catering to the specific fields under the sector. Some of the achievements worth mentioning are as below:

- NEERI maintained and updated the national database on air quality of ten major Indian urban cities, which is extremely useful in air quality management. Studies for assessment of the contribution of vehicular emissions to total air emissions and emission source apportionment studies for Delhi are under progress.
- An innovative process for the treatment of toxic air emissions, using a flue gas treatability system, was designed and constructed at NEERI, Nagpur for small/ medium scale industrial emissions; an appropriate waste management system was developed for handmade paper industries.
- NEERI has developed an inventory of evaporative emissions of hydrocarbons from various sources in Delhi, Kolkata, Mumbai and Chennai based on secondary data, to assess the portion of evaporative emissions of total ambient hydrocarbons and to design suitable control measures.
- A GIS Based modelling tool for site and structure selection for artificial groundwater recharge has been developed at NEERI and conducted studies for development of technologies involving rainwater harvesting and environmental protection of the streams for safe drinking water supply and sanitation for sustainable water resource management in Himalayan villages for the Rajiv Gandhi Drinking Water Mission.
- An extensive assessment was carried out to ascertain amount of soil and nutrient losses due to brick making in state of Assam, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.
- Developed a culture bank of 1050 bacteria from isolates collected from various effluent treatment plants.
- Extensive field investigations and assessment of the advanced treatment processes, employed in eleven textile industries were carried out in Hyderabad, enabled recycle and reuse of wastewater with zero liquid effluent discharge and evaluated existing waste treatment systems of 157 small-scale industries located within 1 km from surface water bodies in various districts of Tamil Nadu.
- The status of municipal SWM in metro cities, state capitals, Class-I cities and Class-II towns was assessed, for CPCB, and a national database on select 59 cities has been established. Based on the studies carried out in 42 cities so far, the waste generation rate has been estimated to be in the range 0.12 to 0.60 kg/capita/day.
- In a pioneering endeavor, NEERI immobilized arsenic bearing hazardous waste at the Zuari Industries Ltd, Goa. The stabilised and solidified hazardous waste was contained in a specially designed landfill. A reinforced concrete cement containment tank, lined with high-density polyethylene (HDPE) liner was designed and constructed for containment of stabilized/ solidified arsenic waste and the spent catalyst.

Technology for chrome recovery & reuse

Cleaner processing options for recovery of toxic chrome which is let out in the effluent, has been developed at CLRI. The technology has been implemented in large number of commercial tanneries & resulted into 98-99% recovery of the chrome. Chrome recovery plants can be established to meet different scales of production starting from individual small-scale tannery to a group of tanneries.

UASB technology complete with sulfur recovery plant

An improved system has been developed at CLRI, whereby unwanted sulphate was completely removed as elemental sulfur and the treatment of the tannery waste water was carried out in conventional UASB reactor, thereby generating energy. This system ensures removal of COD and sulfate TDS by 60% and 90% respectively. Large numbers of plants have been established based on this technology.

Bio-methanation for solid waste disposal

Solid wastes generated by the leather processing industry are posing a major challenge. Appropriate technology has been developed by CLRI for the profitable disposal of these solid wastes. This technology can be used for the disposal of other solid wastes as well. The technology has been implemented in Hyderabad, Aligarh and Chennai.

Chemo Autotrophic Activated Carbon (CAACO) System for Waste water treatment: It is an integrated system of biological and chemical oxidation and saves electrical power consumption to an extent of 75%, as compared to the conventional aerobic system. The treatment eliminates about 92% of suspended solids, 98%BOD, 85% COD, 100%sulfide, 100% odour with high degree of performance consistency. Another major advantage of the system is that the pH of the processed liquor lies very close to the neutral range, thereby facilitating easy disposal of the processed water. The technology has successfully been implemented in several tanneries for treatment of the tannery effluents.

ITRC has helped various government departments in formulating the guidelines for toxicity evaluation of chemicals and products, setting up permissible levels of various additives and contaminants in food and packaging material, evaluation of pesticide residues in food and water.

NML has developed: (i) Technology for control of pollution from foundries operating coke fired cupolas (ii) Cokeless cupolas (iii) Low-cost process for purification of groundwater from toxic metal contaminants.

C-MMACS has contributed to : (i) Integrated Modelling Platform- capacity to model and forecast environmental process at user specified spatio-temporal scales (ii) Accurate, long-range prediction of rainfall pattern - The Neural Network model developed at C-MMACS for long-range forecasting of monsoon rainfall has been successfully used to generate experimental forecasts for the past seven years. (iii) Dynamic Ocean Modelling - Ocean state forecasting for diverse uses like --economic shipping lane to tourism; ocean resource management; estimation of fisheries potential and influence on sea surface temperature; ocean state forecast of the seas around India; prediction of monsoon variability, storm surges associated with cyclones, waves, biological productivity and coastal processes; surface wind flows over the global oceans [1982-1994] and tidal models for the Gulf of Kutch, Bombay High, and Mandovi-Zuari estuary system have been developed.

CSIO has developed (i) Particle Size Analyzer for Textile Industry (ii) Microcontroller-based ozone monitor (iii) Real-time sound analyzer (iv) Microcontroller-based COH and dust mass monitor (v) Some other CSIR laboratories have also contributed significantly to this theme area.

Industrial waste minimization and cleanup

Under this network project some commerciall exiciting results were obtained, as under:

- Developed variety of reactor configurations for waste treatment for the following: (i) Sequencing in batch reactor, (ii) Air lift reactor, (iii) Turbulence bed reactor, (iv) Electrochemical reactor, (v) Submerged lance based smelting reduction (vi) Buoyant filter bioreactor, (vii) Bio-buoyant filter, (viii) Photo catalytic reactor
- Developed a variety of soil remediation measures through following routes: (i) Bioremediation, (ii) Chemical remediation, (iii) Phyto-remediation, (iv) Electro-remediation, (v) Monitored natural attenuation, (vi) Immobilized agents, (vii) Hyper accumulator plants
- Developed know-how for buoyant filter bioreactor technology for treatment of wastewaters for COD removal (14 hr HRT) – technology demonstration with Thermax India is being worked out

Pollution monitoring mitigation systems and devices

Under this network project some scientifically attractive results were obtained, as under:

- Molecular Beacons designed and validated in-silico for *Enterococcus sp*. and *Escherichia coli* serotypes
- Impact of anthropogenic perturbations oceanographic atmospheric Processes in and around India in the context of global change
- Analysis of ground water samples collected from sites of Deccan Plateau & western sector of the Indo-Gangetic plain have revealed that the ground waters are getting loaded with nitrogenous compounds in some places. Investigations have also revealed that both nitrification and denitrification processes are resulting into production of a greenhouse house gas in the ground waters of India.
- In the first ever cruise covering the western and eastern margins of the Arabian Sea and the open sea, data on hydrography, nutrients, chlorophyll-productivity, trace metals, and bacterial diversity was collected. Analysis of the collected revealed that two new processes – copper supported iron limitation and low dissolved oxygen – limiting biological production are taking place in the sea.
- Studies have revealed that $\delta^{15}N$ of surface-water nitrate close to the Arabian coast varied over a wide range (from $\sim$6.5 to $>$13 per mil) indicating the presence of both young (freshly upwelled) and mature waters. In the offshore region, the values were generally higher ($>$12 per mil). The offshore enrichment of ^{15}N in surface nitrate may contribute to the $\delta^{15}N$ maximum ($>$ 11 per mil) observed in surface sediments of the central Arabian Sea, which was previously attributed to the digenesis.

Impact of anthropogenic perturbations an oceanographic atmospheric processes in and around India in the context of global change

The site preference data showed opposite trends in the two environments (Oxygen & Nitrogen) indicating different production mechanisms of nitrous oxide. These results indicate that both nitrification and denitrification processes are resulting in the nitrous oxide (a greenhouse house gas) in ground waters of India. Time series measurements revealed the untimely occurrence of harmful algal blooms in Goa coastal waters

1.6.7 ENERGY: RESOURCES & TECHNOLOGY

Many CSIR laboratories have been engaged in undertaking R&D and developing new knowledge and technologies under this strategically important sector. Today, it has emerged as a major R&D agency with its laboratories contributing towards development of alternate sources of energy and technologies involved in their production, conversion and storage besides delivering incremental innovations in the area of conventional fuels. CSIR has two laboratories directly catering to this sector viz, Central Fuel Research Institute (CFRI), Dhanbad, and Indian Institute of Petroleum (IIP), Deharadun. Other laboratories have some activities pertaining to aspects of specific energy sources for example Central Electrochemical Research Institute (CECRI), Karaikudi on batteries, Indian Institute of Chemical Technology (IICT), Hyderabad on coal gasification, National Aerospace Laboratories (NAL), Bangalore on wind energy, National Chemical Laboratory (NCL), Pune on fuel cells etc. some of the notable achievements are:

Improved soaker visbreaking technology

IIP developed soaker visbreaking technology in use for the reduction of viscosity and pour point of fuel oils. The process is also used for upgrading of residual fraction. Six commercial units based on the technology are under operation. Efforts at IIP in collaboration with EIL and UDCT have lead to further improvement in the technology, which would provide following benefits: increased conversions due to uniformity in temperature and flow profile; decrease in coke deposition in soaker and furnace coils and hence reduction in frequent shutdowns; and increase in selectivity towards middle distillates. The process is energy conserving, the benefits to the user will thus be of the order of Rs. 50 lakh per annum for the plant of 1.0 MMT capacity in saving of fuel oil. In addition, overall throughput will also increase, as the run length will increase, enhancing the productivity.

Oxidative desulphurization of diesel

IIP has developed oxidative desulphurization method for the removal of 4-methyldibenzothiophene (4-MDBT) and 4,6-dimethyldibenzothiophne (4,6-DMDBT). In this process the sulphur compounds present in diesel are first oxidized to sulphones to increase their polarity and subsequently removed by extraction with polar solvent or adsorption. The process is advantageous in the sense that the refractory sulphur compounds like 4,6-dimethyldibezothiophene and its alkylated derivatives, which are extremely difficult to hydrodesulphurize in deep hydrodesulphurization (HDS), can be easily oxidized to sulphones and removed by extraction / adsorption thereby yielding ultra low sulphur diesel with sulphur content below 10 ppm. Therefore, oxidative desulphurization has great potential to be a complementary process to traditional HDS for producing ultra low sulphur diesel (ULSD).

Development of equivalency chart between UHV & GCV of Indian non-coking coals

CFRI in order to develop the equivalency chart used coals from the major coalfields. It is observed from the scatter plot of different coalfields that the variation within a coalfield is significantly less than the variation between the different coalfields. This is primarily because the UHV concept is based on the role of diluents and it does not consider the organic matrix and petrographic mix of the different coals which ultimately decide the inherent heat value and its burning properties. Due to such high regional variations it is suggested that no single relationship can be adopted for evaluating the GCV value rather relationships specific to individual region may be used for categorizing the coals of that region. The study provided a reliable and scientific basis for making the equivalency charts between UHV and GCV, which can be used for grading the coals in terms of the experimentally determined GCV.

Industrial briquetting plant from coke-breeze

CFRI successfully commissioned a briquetted fuel (for industrial use) producing plant within the premises of Gujarat Heavy Chemicals Limited (GHCL), Sutrapada, Varabal, Gujarat. GHCL will be able to reduce import of coke by 15 percent.

Coal washing JIG

Based on the design of CFRI a coal-washing JIG of 30 tph capacity is being manufactured by a private party for commercial washing of both coking and non-coking coals suitable for small-scale entrepreneurs.

An improved method for underground extraction of coal from contiguous seams/sections

CMRI has conceived an idea of underpinning to facilitate safe and optimal extraction of coal from contiguous seams/sections in seams/sections. The system involves conventional system of development of the sections of the seam/seams along the floor with superimposed pillars and final extraction by splitting and slicing by reinforcing the parting from top of the seam/section working with the application of used wire ropes in galleries/splits/slices. CMRI found that underpinning consolidates parting stability through reinforcement and provides additional thickness to the critical parting as the roof coal band of the thick bottom sections was stitched together with the parting.

This technology was introduced at Chirimiri colliery of SECL for simultaneous extraction of contiguous sections of zero seam with critical and laminated parting of approx. 3m thick. This method arrested failure/collapse of parting and provided support of high roof during workings of bottom section of approx. 6m thick. This system has successfully been implemented for optimal extraction of 26 panels of the seam. The method has now been accepted as a regular system of extraction for rest portion of the seam. This method has increased not only the life of the mine but also the mineable property in addition to manpower deployment opportunity

H_2 based fuel cell produced by hydrocarbon reforming

The major components of the fuel cell power pack are: fuel processor, fuel cell stack, power conditioner and reformer. NCL has developed the steam reformer (SR) and preferential oxidation (PROX) catalysts. The know-how for scale-up (kg size) of SR catalysts has been transferred to the industrial collaborator. The catalyst is giving an excellent performance in terms of conversion as well as hydrogen yield. Preparation of platinum based PROX catalyst is scaled up to 500 g size at catalyst pilot plant of NCL. The processor, NCL has designed, is compact, light weight and can be adopted for different fuels.

NCL has also designed two reformers with an individual capacity to produce 1000 LPH of hydrogen. Fuel processor with both the reformers is operated for hundred hours with same operating conditions. The high temperature shift (HTS), low temperature shift (LTS) and PROX reactors are identical in both cases. The CO concentration after PROX is reduced to 20-25 ppm range. In the fuel processor, 97% conversion of LPG obtained.

Thermally stable cation- exchange membrane for fuel cell

CSMCRI has developed a novel method for the preparation of thermal stable and chemical resistant ion exchange or proton-exchange membranes by eco-friendly route in aqueous medium. Organic-inorganic hybrid membranes were prepared based on polyvinyl alcohol/SiO2, under acidic and basic conditions, in which sulfonic acid groups were introduced at the inorganic segment.

New processes for fuel cell membrane

NCL has developed two new processes to obtain high-purity diaminobenzide (DAB) the monomer that is used to prepare polybenzamidazole (PBI) membranes for fuel. The first process uses a non-carcinogenic raw material (nitro-bromoacetamide or NBA) and a novel, highly efficient catalyst. The second method (from dichlorobenzidine or DCB) involves a three-step process with a novel catalyst called titanium superoxide. Both the processes yield highly pure DAB (100 per cent purity) with no by-products. The processes use novel catalysts that make it possible to carry out the reactions under milder, safer conditions. These processes represent a significant advance that will enable the production of PBI membranes for fuel cell applications.

Monolayer cathodes for lithium batteries

NCL has demonstrated that a cathode prepared from a single layer of molecules can be used for high-energy rechargeable lithium batteries. It could reduce the weight of the battery drastically. For the first time a self-assembled monolayer of an organic molecule (a disulphide) has been used to prepare cathodes. Self-assembled monolayers (SAMs) are closely packed arrays of organic molecules, can be easily prepared and are very stable. The SAM coated gold was used along with a lithium electrode to prepare a lithium battery that gave an open circuit voltage of 2.9 V.

Supercapacitors

CECRI has evolved a new preparative approach to configure a supercapacitor electrode by interfacial polymerization leading to carbon-polyaniline nanofibre matrix. This method utilizes the template free generation of polyaniline nanostructures with small diameter (sub 100 nm), which can easily be incorporated into porous carbon matrix of uniform size and also in bulk quantities. The electrodes of this composite matrix displays faster rate of doping-dedoping compared with conventional polyaniline and thus hold a promise as an efficient supercapacitor electrode. Screening of this electrode for capacitive charging-discharging indicates higher order of specific capacitance (over 150 F/g) in comparison to conventional polyaniline electrode.

Developing new generation fuel and lubricants

This network project has several strategically important goals, encompassing development of Gas to Liquid Technologies for DME and FT Fuels, Liquid Fuels form Biomass, Ethanol from Biomass, Development of biodegradable lubricants from vegetable oils, sugars, starch and cellulose, Development of catalysts for atmospheric residue processing. Performance evaluation of new generation automotive fuels to meet emission norms.

Most of the participating laboratories could create capacity to undertake R&D specific to goals as mentioned above.

Coal characterization & resource quality assessment for specific end users

This network project had a broad mandate to characterize and asses coal quality from various coal bearing regions. Studies are on with respect to the objectives.

Quality enhancement of coal for its efficient utilization

This network project has aims to address specific needs of a few coal bearing areas, notably Talcher and IB valley. R&D intervention is on to improve the quality of coal as obtained.

1.6.8 ELECTRONICS, PHOTONICS & INSTRUMENTATION

Two CSIR laboratories, Central Electronics Engineering Research Institute (CEERI), Pilani and Central Scientific Instruments Organization (CSIO), Chandigarh are exclusively devoted to R&D for electronics and instrumentation; besides other laboratories viz, Central Glass & Ceramic Research Institute, Kolkata and National Physical Laboratory, New Delhi have expertise and facilities to contribute on specific aspects of electronics. In addition several of the CSIR laboratories with specific mandates also carry out R&D activities such as; analytical instrumentation, avionics for aerospace, robotics for mechanical applications, autonomous pressure based tide gauges, weather stations, surface vehicles for oceanic process, and geophysical instruments. Some of the achievements are:

New sensors for trace moisture analyzer

Detection of gaseous moisture in ppmV level is very important in certain industries. CGCRI has developed a device to detect moisture in the range of 0-1000 ppmV based on micro and nano-porous alumina sensors. Important areas of application of these trace moisture analyzers are in measurement of moisture in gases of glove boxes as well as in industrial environment involving high quality welding, nuclear reactors, food pack aging, pharmaceuticals, laser marking, submarine periscope purging, etc.

Non-Linear junction detector (NLJD) for explosives

CSIO has developed a portable, field operatable hand-held NLJD system, which is an advanced detector using the Harmonic Radar principle to aid the security professionals in the search of concealed electronic devices and other similar items such as timers or remote control receivers for detonation of explosive dormant and non-operational devices. CSIO is the first to develop this instrument indigenously.

Highly sensitive explosive detector

CSIO has developed a highly sensitive explosive detector. The instrument works on the principle of gas chromatography, which separates the mixture of volatile compounds when they flow through the chromatographic column containing a stationary phase, through which the stream of inert gases passes continuously.

Fast optical pyrometer for transient explosion temperature

CSIO has designed & developed a Fast Optical Pyrometer to measure transient explosion temperature in the range of 1,000-10,000 K where the detonating response time is of the order of 100secs. The instrument consists of focusing optics, fiber optic beam splitter (50/50), interference filters, optical to electrical (O-E) converters and application software.

Clinical chemistry analyser for blood biochemical parameters

CSIO has developed Clinical Chemistry Analyser, which is a high performance Micro-controller based photometric biochemistry analyzer used to measure various blood biochemical parameters such as Blood Glucose, Urea, Protein, Bilirubin etc. that are associated with various disorders such as diabetes, kidney diseases, liver malfunctions and other metabolic derangements. The quantification of these parameters is helpful in classifying such diseases and under appropriate circumstances results of the system are used for diagnostic purposes.

Pneumatically driven anesthesia ventilator

CSIO has developed a pneumatically driven Anaesthesia Ventilator, which delivers a specific volume of breathing gas to a patient at a desired breathing rate. It also maintains required duration for inspiration and expiration.

Digital moisture probe

CSIO has developed a system for moisture measurement, which is based on variations in conductivity. This increases with increasing moisture. It has sensing system, microcontroller and display unit. The sensing system consists of two special metallic sensors embedded in a probe, electrically insulated, except at contact point near the tip where moisture of the oil seeds and grains is registered. It is simple to use, accurate, versatile with minimum controls to determine moisture content. Automatic temperature compensation has been provided to ensure optimal accuracy.

Coefficient of haze and dust mass monitor

CSIO has developed Microcontroller based coefficient of haze and dust mass monitor, which determines the instantaneous and average level of black dust mass concentration along with Coefficient of Haze (CoH) at ground level. A pump draws air at a predetermined constant flow rate through a sampling head and the dust particles are allowed to deposit on a filter for a fixed time. A dust spot is, therefore, formed on the filter paper proportional to the dust load in the ambient air. Before the sampling of dust, the microcontroller (8051) reads the intensity of transmitted light through blank filter paper (I_0) and latches this data in the memory. At the end of sampling time, the spot on the tape is moved in front of photo detector very precisely with the help of a stepper motor. The motion of the stepper motor is controlled by microcontroller.

Radiation resistant optical components for CCTV nuclear camera

CGCRI has developed, fabricated and supplied complete optical system for an indigenous CCTV nuclear camera used for remote viewing of the interior of the reactor coolant tubes. This remote is very important for effective and timely servicing of the nuclear reactors. The system is required for focusing, illumination, mirror rotation, etc. to aid viewing for remotized controls. The device developed at CGCRI replaces the earlier ones, which were being imported and are not readily available.

Special electron tube technologies for large-scale applications

This network project covering a large number of applications could achieve appreciable results as under:

➲ Long Life Cathodes

These Cathodes have been developed. The accelerated Life tests on first batch is progressing well and has logged 4000 hours of life without any degradation in emission. Thermionic Emission Microscope is also being developed.

➲ Depressed Collector for High Efficiency TWTs

To reduce the secondary emission, multi-stage depressed collector has been developed using special high-density graphite. The necessary ceramic components have been developed by CGCRI. CMERI is developing an alignment tool for this project. The evaluation of this collector is being done on a gun-collector assembly with ultimate goal of replacing it with the conventional collector of a high efficiency TWT.

➲ High Average Power (30 kW) RF Window

The pillbox type rf windows have been developed. Their cold rf performance (Return and Insertion loss) is satisfactory. Their thermal simulation is being done using ANSYS.

➲ Characterization of Microwave Tubes and Sub-assemblies

This facility has been created to carry out characterization as well as defect evaluation at various stages of development.

➲ Plasma Devices

This has two activities (i) Development of 25 KV/5KA and 40 KV/5KA Plasma Switches and (ii) DBD based VUV/UV Source. 25 KV/5KA switch has been developed and undergoing tests. Design of 40KV/5KA switch has been completed. As regard DBD activity, all related infrastructure has been developed and some initial experiments done to have this discharge.

➲ Pulse Power Systems

A 10KV/10A Pulser has been developed for Cathode Project and has given required performance. Another multi-electrode power supply is also being developed for evaluation of depressed collectors.

➲ Special Ceramic Components (CGCRI, Kolkata)

They have successfully developed various ceramic components for the Collector project. Special metallization and plating techniques have also been developed. They have also developed a special material (Hexa Boron Nitride), which is equivalent to APBN, which has much use in TWTs.

➲ Laser Assisted Alignment Tool (CMERI, Durgapur)

This alignment system is being developed by them for alignment of Microwave Tubes. The very first model has been developed by them. They have also assisted in thermal evaluation and fabrication of collector components.

Developing capabilities and facilities for Micro-electromechanical Systems (MEMS) and Sensors

Under this network project, CEERI has developed a smart biosensor based on ion-sensitive field effect transistor (ISFET) with suitable packaging know-how.

ISFET biosensor has been fabricated using metal gate NMOS technology with the Glucose Oxidase (GOD) enzyme immobilized over the silicon dioxide-silicon nitride dual-dielectric gate in place of the conventional metal gate electrode. The device has a high aspect ratio (W/L~400) N-channel enhancement mode FET with inter-digitized source-drain geometry and the channel length of 12 μm. The ISFET chip has been mounted on ceramic substrate and the wire bonds have been protected with insulating epoxy.

The device has biomedical applications e.g. in clinical pathology and food and beverage industry. Advantages include; small size, instant response, ruggedness, mass scale production, low-cost and reliability. The device has impact on health care and food processing instrumentation.

A surface micro-machined capacitive pressure sensor having high sensitivity, low-cost and surface micromachined capacitive pressure sensors with chip Size – 4 mm x 3.2 mm, chip Thickness – 0.5 mm, configuration – 10 x 10 Arrays, pressure range – 0-700 Psi has been developed by CEERI under this network project. The packaging of this sensor can be done as per the user demand and is compatible with CMOS VLSI.These sensors find application in number of strategic areas like space, atomic energy and defene. Industrial applications in automobile, structural health monitoring and process control instrumentation needs a large variety of these sensors in different package configurations. A variety of sensors are also needed in human health related miniaturized diagnostic instruments. The demand of these is expected to grow extremely fast in times to come.

Development of key technologies for photonics and optoelectronics

This network project which aimed to develop an optical fibre amplifier has been able to report the development of an Optical amplifier for light wave telecommunication network using erbium-doped optical fibre (EDF) and power semiconductor pump laser source. The amplifier gain block with all necessary logic control and computer interface commensurate with CATV and Telecom standards has been designed and developed by CGCRI with an industrial partner, NeST, Cochin. 980 nm pump laser diode, a key component of C-band optical amplifier has been developed by CEERI and packaged by an industrial partner M/s Optiwave, Hyderabad. This device has been tested successfully in EDFA system for performance and reliability delivering about 90 mw power at 980nm.

Electronics for societal purposes

This network project with ambitious objective could develop an electro optical System for Sorting, Grading and Packaging of different fruits, vegetables and grains like rice etc.; Monitoring & Control System for Food Storage Houses and Optimisation of Process Parameters; develop intelligent Prosthetic Devices for Rehabilitation of Physically Challenged; develop *myoelectric arm* currently under trials. likewsie a voice operated electronic hand under clinical trials are in progress at Saket, Chandigarh; and a porotype functional Electrical Stimulation System whose Preliminary clinical trials have been conducted on a paraplegic patient at Government Medical College & Hospital (GMCH), Chandigarh.

1.6.9 ENGINEERING MATERIALS, MINING/MINERALS & MANUFACTURING TECHNLOGY

CSIR recoganized the importance of materials & mineral development, cost effective technologies for manufacturing, and coal mining & fuel in the socio-economic development of the nation as early as in the fifties. Today it has emerged as a major R&D agency with its laboratories contributing towards various aspects of materials, minerals, mining and manufacturing. CSIR laboratories: National Metallurgical Laboratory, Regional Research Laboratory-Bhopal, Regional Research Laboratory-Bhubaneshwar, Regional Research Laboratory-Jorhat, Regional Research Laboratory-Trivandrum, are exclusively devoted to R&D for minerals & materials their characterization, processing, new materials etc. Central Glass & Ceramic Research Institute caters to the R&D need of ceramic and glass industries. Central Fuel Research Institute and Central Mining Research Institute address the R&D issues of coal mining, characterization, beneficiation etc. Central Mechanical Engineering Research Institute works on mechanical product design and manufacturing technology. Other laboratories viz, National Chemical Laboratory, Indian Institute of Chemical Technology, National Physical Laboratory, and Central Electrochemical Research Institute have expertise and facilities to contribute on specific aspects of the sector. Some notable achievements under the sector are:

Bioactive integrated orbital implants

When the eye of a person is damaged due to disease or injury, the surgeon removes the eyeball from the orbit (eye socket) to avoid the risk of life/the risk to the other eye of the patient. The lost eye can be mechanically replaced by an orbital implant to fill up the orbital volume lost after enucleation/evisceration to achieve better cosmetic and rehabilitation of the anophthalmic patient. This artificial eye is very light (less than 2 gms.) and costing only Rs. 2000/- compared to around Rs. 25000/- for the imported ones. The technology has been transferred to M/s IFGL Bioceramics Ltd., Kolkata.

New method to utilize steel plant waste economically -briquetting

Laboratory scale studies have been conducted on cold briquetting, using inorganic binders to achieve high green and cold crushing strength. On the basis of the results, large-scale trials on 30 tph capacity have been successfully conducted at the plant site of M/s. Ispat Metallics India Ltd. The briquettes produced during the trial runs have undergone various metallurgical tests such as RDI, Tumbler Index, etc. and found to be suitable for charging to blast furnace.

New technology developed to manufacture DRI blocks by utilizing the Iron bearing fines and coal/char/coke fines for use in steel-making

RRL-Bhubaneswar has developed a process to produce composite blocks of iron ore fines and solid waste fines using suitable binder combinations followed by reduction roasting in non-oxidizing/mild reducing condition in a coal fired furnace. These highly metallised DRI blocks can be charged into the induction furnace for steel making. This is a new and simple technology for making steel by utilizing waste fines generated in the mines as well as industries and is proposed for the first time in the country.

Fullerene doped glasses

CGCRI has developed a series of fullerene C_{60}-borate glasses composites of optical quality bearing high concentration of C_{60} and their nonlinear optical properties were studied to identify their suitability as Non-Linear Optical (NLO) materials. These composites show moderate third order nonlinear optical properties and good optical limiting properties i.e. they can limit the transmission of high intensity light and hence can serve as a protector of laser detectors.

Special fibres for writing fibre Bragg-grating (FBG)

Fibre optic Bragg grating (FBG) in different configurations have found major applications in Er-doped fibre amplifier (EDFA) and provides practical solutions for laser wavelength stabilization, pump wavelength filtering and gain flattening in multi-channel wavelength amplification for reducing problems of non-linearities encountered in optical network. CGCRI has fabricated preforms containing suitable dopants in the core in different proportions by Molecular chemical vapour deposition (MCVD) process and fibres were drawn from the preforms with online resin coating.

Water mist- an effective agent for controlling open fire in underground Mines

CMRI, after detailed investigation proved that water mist infusion is safe and very effective technique for not only controlling open fire in underground mines but also reducing toxic gases, minimizing backlash and improving visibility in the fire affected area. The average reduction of temperature was found maximum (294°C per hour) after spraying of water mist, whereas it was 207°C per hour in case of high-pressure high stability (HPHS) nitrogen foam.

Recovery of cenospheres from fly ash

RRL-Bhopal has developed a novel process for the recovery of cenospheres from fly ash. Indian coals contain high ash content and during generation of thermal energy by coal combustion a large quantity of fly ash is generated. Cenospheres are lightweight, inert and nonmetallic hollow ceramic spheres found in fly ash in sizes below 500µm. The shell is composed of silica and alumina and hollow space inside is filled with gasses like N_2 or CO_2.

Polymetallic nodule

RRL,Bhubaneswar has developed a flow sheet for processing the ocean nodules through hydrometallurgical route. A pilot plant for testing the entire flow sheet has been put up by EIL-HZL at C.R.D.L of HZL, Debari, Udaipur with the assistance of the laboratory. The process would be further scaled up on the basis of the data generated through trial runs at the plant.

Custom tailored special materials

Several special materials could be prepared such as: Gold (Au) nanocluster doped films in SiO_2 and mixed SiO_2-TiO_2 hosts prepared on glass substrates and characterized by different techniques. A process for solid state processing of $Ba(Mg_{1/3}Ta_{2/3})O_3$, $Ba(Zn_{1/3}Ta_{2/3})O_3$ and $RETiNbO_6$ and $RE'TiNbO_6$ ceramics has been developed. Porous nano alumina powder and tape cast multi layer composites (MLC) of 3, 5, 10 and 20 layer configurations were prepared to about 63 to 70% theoretical density. These MLC samples showed much higher failure energy (10 -70 KJm^{-3}) than that (4.38 KJm^{-3}) of the porous nano alumina single tape. A new series of $La_2Mo_2O_9$ based oxides of the general formula $La_2Mo_{2-x}Nb_xO_9$ where $x \leq 0.4$ were prepared by a citrate-nitrate combustion process and the electrical and thermal properties were evaluated. The composition with the lowest Nb-doping, viz. $La_2Mo_{1.94}Nb_{0.06}O_9$, exhibited a conductivity of 0.113 S/cm at 800°C, which is nearly double that of the undoped material and this is the highest value so far reported in this family of oxides.

Capacity building for coastal placer mining

As an objective of this network programme, sampling and beach profiling of placer deposits along Nagoor-Poompukar coast in East Coast, South Maharashtra Coast in West Coast and Goa beaches was carried out. Validation of GPR data with ground truth has been established for east coast of India. Computer software named PLACER FLOW has also been developed.

Bio-mineral processing for extraction of metal values from ore/concentrates and wastes

This network programmes seeks to address a few R&D issues of importance to missing industry, wherein bioleaching of lowgrade copper ore of Malanjkhand (0.3%) and uranium (UCIL 0.02%U) was taken up and laboratory scale bioleaching work in shake flasks were carried out using low grade ore by varying parameters like pH, pulp density and particle size. The copper recovery was around 40% in 50 days at a pulp density of 20% and uranium recovery was more than 70% in 30 days of leaching.

Technology for engineering criticality analysis

Several achievements have been reported under the network programme; such as development of magnetic non-destructive evaluation system for microstructural degradation of components at elevated temperatures; development of software for measurement of thin coating layers and oxide scale thickness, and prediction of remaining life of boiler components therefrom, and development of framework of software for remaining life prediction of corrosion affected critical RC structures due to carbonation and chloride ion attack.

Developing capabilities in advanced manufacturing technology

This project with some ambitious goals a VR Lab was set up with facility of simulation and visualization in impressive environment to undertake expeditious development of Shakti tractor prototype.

Further CGCRI along with CMERI has developed the dental implant (with threaded/smooth surface) made of Ti-6A1-4V alloy and coated with hydroxyapatite (HAp) under the above network project. Human trials with the implants were also carried out with this technique at Main Hospital, Durgapur before dental surgeons. The HAp coated dental implants are being evaluated *in-vitro* and *in-vivo* and the results are encouraging. Yet another component was optimization of process parameters for Metal Injection Moudling for use in the production of engineering components. Broad areas for collaboration with TATA Motors have been already identified and an MOU has been signed. Three components of TA65 gear box of Indica car identified for development through MIM process. In addition firearm components from Ichapur Rifle Factory have been selected by the nodal lab for manufacturing through MIM.

1.6.10 PHARMACEUTICAL, HEALTHCARE & DRUGS

CSIR has a full fledged institute devoted to Drug R&D viz, Central Drug Research Institute (CDRI), Lucknow, besides other institutes which have major programmes in the sector include: Central Institute of Medicinal & Aromatic Plants (CIMAP), Lucknow, Indian Institute of Chemical Biology (IICB), Indian Institute of Chemical Technology (IICT), Institute of Microbial Technology (IMT), National Chemical Laboratory (NCL), Regional Research Laboratory, Jammu, Centre for Cellular and Molecular Biology (CCMB), Central Leather Research Institute (CLRI), Central Salt & Marine Chemicals Research Institute (CSMCRI), Institute of Himalayan Bioresource Technology (IHBT), Industrial Toxicology Research Centre (ITRC), National Botonical Research Institute (NBRI), and National Institute of Oceanography (NIO). Some of the notable achievements under the sector are summarized below:

Malaria

- CDRI developed blood schizodonticidal drug Arteether (brand name E-mal) has been approved by Drug Controller General (I) for Phase III clinical trials among children. Multi centric chemical trials are in progress to establish efficacy of the drug in children suffering from *Plasmoduim falciparum* malaria.
- CDRI has identified a synthetic antimalarial trioxane compound 97/78 as a substitute to the naturally occurring artemisimnine. The compound exhibited significant antimalarial activity in pre-clinical studies and safe profile in regulatory pharmacology and systemic toxicity in rodent models. A collaborative cum licensing agreement has been signed with IPCA Laboratories, Mumbai for development of the drug. Another promising anti malarial trioxane compound 99/411 is under pre-clinical evaluation.
- NIO has prepared the crude extract by the enzyme-acid hydrolyzing process from a marine organism (mussel) which shows initially a potent anti-malarial activity, at least when examined for *in vitro* cultures of *Plasmodium falciparum* in human erythrocytes. The molecular entity(ies) responsible for anti-malarial activity was isolated & characterized and named as NIO-l and NIO-2. Mumbai-based company Shreya Life Sciences has been licensed to commercialize the drug.
- CDRI has established a modified culture medium, using 10% fetal calf serum instead of human serum, for laboratory maintenance of *P.falciparum*. The cultures successfully maintained for over 6 months showed growth rate comparable to that recorded with 10% human serum.

Cancer

- CDRI synthesized substituted phenanthrenes with basic amino side chains and some of them showed remarkable anti-proliferate activity against ER positive MCF-7 cell line with IC_{50} in the range of 3.5-22.2 mM. One of the compounds showed anticancer activity in 7, 12-dimethylbenz(a)anthracene induced hormone dependent mammary tumor in rat. The activity was comparable to that shown by tamoxifen.
- IICB has identified and established Sodium chlorogenate as a potential anti-chronic myelogenous leukemic drug and transferred the Know-How to M/s. Nicholas Piramal India Ltd. for further development and commercialization.

- IICB has discovered and isolated a compound from the leaf of the betel plant (*Piper betel*), which induces death of cancer cells in chronic myeloid leukemia (CML), a type of cancer that attacks white blood cells. The compound, has the same structure as chlorogenic acid (*Chl*), and kills cancerous CML cell lines without harming normal cells.
- IICT has designed and synthesized a number of new pyrrolobenzodiazepine and podophyllotoxin structure based molecules that exhibited promising anticancer activity. About 4 to 5 lead molecules have been selected for preclinical studies. Five US patents have been licensed to IndUS pharmaceuticals, USA for preclinical and clinical development.
- RRL-Jammu has isolated a natural compound from *Boswellia* species, as well as alternatively prepared its semi-synthetic compounds for cancer of colon, prostrate, liver, breast, central nervous system (CNS), leukemia and malignancy of other tissues, including ascites and solid tumors. The pharmaceutical preparation has shown lower toxicity and therefore, would be well tolerated by the patients.
- RRL-Jammu has identified the cytotoxicity and anti-cancer activity of an essential oil, alone or in combination with pharmaceutically acceptable or other carriers, of a new chemotype from *Cymbopogon flexuosus* (Nees ex Steud.) Wats [RRL(J)CF HP] for prostrate, lung, colon, cervix, ovary, breast, leukemia, liver, neuroblastoma and oral cavity cancer and ascites and solid tumors. The oil regressed ascites and solid tumors in mouse tumor models.
- RRL-Jammu has also established the anticancer activity of an extract and fraction isolated from flowers of *Butea monosperma* against hepatocellular carcinoma at composition containing marked flavonoid glycosides such as butrin and isobutrin in the range of 2 to 9% by weight.

Cardiovascular disorders

- IMTECH has developed and licnced a process for high-level production of recombinant Staphylokinase. Staphylokinase is produced intracellularly using genetically engineered strain of *Escherichia coli*.
- IMTECH has also developed technology for production of the life-saver thrombolytic drug, streptokinase, from a natural strain, which has been transferred to M/s Cadila Pharmaceuticals Ltd., Ahmedabad and is being produced indigenously for the first time.
- IMTECH has standardized a laboratory-scale process for the preparation of engineered recombinant and also clot-specific streptokinase. The technology for preparation of clot specific streptokinase has been transferred to M/s Nostrum Pharmaceuticals Inc., USA and for recombinent streptokinase to M/s Shasun Drugs and Chemicals Ltd.
- CDRI has identified and developed a lipid lowering compound **80/574.** The compound has been approved by DCG(I) for Phase-III multicentric clinical trials. The clinical trial protocols and case records have been finalized and a collaborative cum licensing agreement for completion of Phase III clinical trials has been signed with M/s Cadila Laboratories, Ahmedabad.

Diabetes millitus

- IGIB through a public-private partnership with Bharat Biotech India Ltd., Hyderabad, has commercialized two important formulations: one as a brand name Regen-D^{TM} -60 for skin graft and burn injuries, while the other, Regen-D^{TM} -150, meant for diabetic foot ulcer. Diabetic foot ulcer is a major complication of diabetes. In general, diabetic foot ulcers are difficult to heal, become readily infected and gangrenous and frequently lead to amputation. **This work has been recognized by a national award (Technology award, 2006).**

- CDRI has completed double blind pilot study of Plant **CT-1** in 55 patients of diabetes mellitus. A new protocol for phase-1 clinical trials by incorporating expert suggestions is planned in consultation with NPIL.
- CDRI has completed Phase-I single dose tolerance studies of the compound CDR-134D123 in 31 healthy human volunteers and Phase I multiple dose tolerance studies are under progress at Seth G.S. Medical College and KEM hospital, Mumbai.
- IICB has isolated an active anti diabetic molecule from the plant, *Pueraria tuberosa*, and established it as a potent drug for diabetes type –II.

Leishmaniasis

- IICB has established Amarogentin, Diospyrin and Dihydrobetulinic acid from natural sources and three synthetic compounds of indolylquinoline derivatives as promising anti-leishmanial compound and their re-evaluation as anti-leishmanial drug is going on in foreign laboratories. The laboratory has further identified a natural pentacyclic triterpene (18β-glycyrrhetinic acid) of *Licorice* root as a potential immunomodulator to generate the required immunity not only for the treatment of non-healing leishmaniasis but also for the treatment of other chronic infectious diseases.
- CDRI has established stable cell lines expressing luciferase gene by using four *L. donovani* field isolates and tested them for sensitivity to antimony under *in vitro* condition.

Tuberculosis

- DNA ligases are important enzymes of *Mycobacterium tuberculosis*, CDRI has identified them as novel, validated and attractive drug targets against the bacterium. The laboratory has been successful in reporting for the first time the crystal structure of the adenylation domain of the *M. tuberculosis* LigA with bound AMP
- IGIB has identified , a few proteins such as Ser/Thr kinase (PknF) and Nucleoside diphosphate kinase (mNdK) as crucial drug targets *Mycobacterium tuberculosis*. PknH was found to regulate conversion of lipmannan into lipoarabinomannan by controlling expression of arabinosyl transferase.

Liver disorders/disfunctions

- CDRI has completed the Phase II clinical trials of the hepatoprotective formulation Picroliv and DCG(I) has approved the same for phase III clinical trials. Phase III clinical trial are in progress in patients of alcoholic cirrhosis group, tuberculosis group receiving MDT and patients on AKT.
- RRL, Jammu developed a single plant based standardized Hepatoprotective agent useful for the treatment of liver disorder such as alcoholic & viral cirrhosis. The process of extracting the formulation has been standardized on the basis of two marker compounds. The technology has been transferred and demonstrated to M/s Medley Pharmaceuticals Ltd., Mumbai. Medley has already released the product in the market and has named it as LIV-1.
- RRL, Jammu developed yet another single plant based herbal product for liver diseases such as Cirrhosis and Viral Hepatitis. The formulation is standardized on the basis of single marker compound isolated from the plant namely *Colebrookea oppositifolia.* The formulation has been licensed to M/s Ochoa Laboratories Ltd., New Delhi. Presently clinical studies are in progress on this product on 60 adult patients at Safdarjung Hospital, Delhi and V. Mahavir Medical College, New Delhi. The Ochoa Laboratories propose to release the product as Liverage in the market.

Osteoporosis

- CDRI has developed the compound 99/373 that has shown better anti-osteoporosis activity than raloxifene, during pre-treatment studies on rat. The compound is devoid of any major CVS and CNS side effects on mice and rats found safe in 28 days toxicity studies. It has high therapeutic value.
- CDRI has, for the first time, establish the osteoblast cell culture from neonatal mouse calvarial cell to confluency. The culture had been used to for establishment of three assay systems. During assay, one of the plant extract, NP-1, showed promising osteogenic activity *in vitro*, and is under product development stage. The culture has also been used to test forty synthetic compounds and three natural products for their anti-osteoporosis activity. Two of the forty compounds showed promising activity
- RRL, Jammu has developed a process for the extraction of an enriched extract of calcitriol from a plant found in south India which accumulates this compound in trace amounts. Calicitriol is physiologically active form of Vitamin D_3, which plays an important role in uptake of calcium in intestines and bones. The drug has therefore an important role in osteoporosis and skin disorders like psoriasis. The technology for the production of the extract has been scaled up to the pilot plant scale and transferred to M/s Genova Biotechniques, Hyderabad. The company has already started the production of the extract for marketing in India.

Immunomodulators

- RRL,Jammu has identified plant based molecule as immunostimulator and tried it with hepatitis vaccine as adjuvant replacing $Al(OH)_3$. . The molecule, RLJ-NE-299A is at the advanced stage of its development as an adjuvant in collaboration with DST and Bharat Biotech Ltd

Stroke

- CDRI has developed a herbal medicament which has shown promising anti-stroke activity along with antioxidant and anti-inflammatory properties on pretreatment in rat. It has been licensed to M/s Themis Medicare Limited, Mumbai under a collaborative-cum-license agreement for the development of the product.

Memory improvement

- CDRI has evaluated standardized brahmi extract in elderly subjects for age associated memory impairment and attention deficit hyperactivity disorder in pediatric cases and found this extract effective against these disorders. M/s Lumen Marketing Company, Chennai has launched this product under the trade name "PROMIND". It has also been promoted and marketed with two different trade names viz. MEMORY POWER and MEMORY PERFECT.

Diagnostics

- IGIB has identified common single nucleotide polymorphisms (SNPs) and haplotypes in asthmatics and healthy individuals from an Indian population. The influence of β2 AR SNPs in responsiveness to β2-agonist therapy in asthma patients was determined. It was found that patients with a homozygous Arg-16 form at nucleotide position 46 are poor responders and patients with a homozygous Gly-16 form are good responders with high probability values. This is the first novel pharmacogenomics discovery in Indian population and has potential to become a predictive diagnostic marker.
- IGIB has reported for the first time, computational HIV-I genome screening by using human micro RNAs for identifying targets. Micro RNAs are increasingly being shown to play vital roles in development, apoptosis and oncogenesis by interfering with gene expression at the post transcription level.

- CDRI in collaboration with Department of Biotechnology has developed and evaluated PCR based Tuberculosis Diagnostic Kit for its sensitivity and specificity in clinical samples. The process know-how for the preparation of specific DNA probes and oligonucleotide primers were developed and licensed to M/s Biotron Health Care Ltd., Mumbai for manufacturing and marketing the product as PCR based Tuberclosis diagnostic kit.
- IICB has developed technology for Ultra sensitive Dot-ELISA or ELISA for detection of biologically important molecules.
- IICB has developed a device for the measurement of human limb movement in 3D space with special reference to Parkinson's disease.
- IICB has developed a novel process for the detection of immune-complexed 9-0-acetylated sialoglycoconjugates (9-OACSGS) in the serum for its use in diagnosis, monitoring treatment outcome and prediction of relapse of childhood acute lymphoblastic leukemia.

Vaccines

- IICB has developed a DNA vaccine against visceral leishmaniasis, in experimental animal model.
- An oral recombinant cholera vaccine developed by IMTECH has now entered pre-phase III clinical trials.

Drug delivery systems

- IICT has developed a technology for oral delivery of insulin and Hepatitis B vaccine.
- CDRI had established a computational model based on stochastic differential equations for predicting optimal drug delivery profile. Transdermal delivery systems were prepared and demonstrated *in silico* to possess the ability to inhibit the male reproductive hormone.
- CDRI licensed the process know-how for vegetable Capsules from Tamarind seed polyose to M/s Strides Arcolab Ltd., Bangalore for commercial application.

Bioinformatics in health & drug development

- IMTECH in collaboration with bioinformatics company BioMantra, launched an immunoinformatics software tool 'VaxiPred' for computer aided vaccine design. This new software tool helps in the prediction of vaccine candidates from a pathogen, thus reducing time in vaccine development. This software tool is an integrated version of 14 different immunoinformatics based software programmes developed by IMTECH for discovering antigens of the disease causing pathogens.
- CDRI in collaboration with Invenio Biosolutions, New Delhi has developed a drug discovery software platform named 'DD Assist' to accelerate and facilitate knowledge based drug design and discovery process. The institute has also developed an expert system **(MENEXSYS)** for prediction and classification of ^{1}H NMR spectra of CSF of children suffering from meningitis.
- CCMB has developed a database PSSARD relating protein sequence to structure/ function prediction and drug discovery. The database is easy to use, web-based computational tool to search proteins in the Protein Data Bank (PDB).
- CCMB has developed another database and a application software called HETGRPANAL, identifies all known hetero-groups in protein tertiary structure such as, metal ions, prosthetic groups, drugs, sugar, peptides containing non-standard amino acid residues, and so on. Further, it can accept the PDB file name and the hetero-group and determine all neighboring atoms in the protein structure in Angstrom units. These models are useful to design new chemical entities that may become potential drugs.

- IGIB has developed Geno-cluster a Bio R&D Software tool for facilitating new drug discovery. The components of geno-cluster are :
  - **GeneD'CFER** for gene identification and structure function studies based on evolutionary conserved peptides.
  - **Proteome Calculator** for computational applications to study several proteomes at one go by performing set theory operations like union, intersection, difference and inverse.
  - **SEAPATH** designed to overcome functional problems for prediction of virulent proteins
  - **PLHost** for annotation and homology of small peptide. It gives accurate prediction of functional sequence.
- IICT has developed a method named **Herboprint** for finger printing of herbal medicines by using a liquid chromatographic method which is useful for understanding the basic concepts of traditional philosophies in identifying the disease in a person and to prescribe suitable medicines for the diagnosed disease.

Asthmatic and allergic disorders mitigation mission

As salient achievement under this network programme. 12 lead molecules have been purified or synthesized. Two molecules inhibited 5-LO, one molecule inhibited c-PLA2, nine molecules inhibited Phosphodiesterase 4, one molecule inhibited Inflammatory cytokines.

In mouse model of bronchial asthma, two lead molecules have been tested so far and both of them inhibited asthma manifestation and one of them inhibited asthma-associated parameters (total IgE and eosinophilia). In vivo toxicity studies have so far been completed on these two molecules; both of them have wide therapeutic window.

Discovery, development and commercialization of bioactives and traditional preparations:

A very ambitious network project; salient achievements include screening of about 16000 samples (12000 plants and ~ 4000 microbial) for various diseases (viz. malaria, tuberculosis, hypertensive, depression, anxiety, dementia, ulcer, cancer and filariasis. The confirmed hits have been converted into 65 discovery groups out of which 13 discovery groups have reached an advance stage of single molecule (9nos) or have shown promise as herbal preparation(4nos). Development of four herbal formulations is the area of ulcer, dementia and cancer and nine single molecules are for cancer, dementia hypertension,Leishmania, hepatoprotective and immunostimulatory have also been reported..

Setting up a world class drug research institute

As a project it is underway, wherein Hydrological Survey work has already completed by U.P. Jal Nigam, Lucknow and their investigation report on Ground Water has been received. Soil investigation work awarded to CBRI is expected to be completed within two months. Lucknow Development Authority has granted conditional approval to the Layout Plan of new CDRI Campus which calls for completion of certain formalities.

Advanced facility of safety evaluation of genetically engineered/modified drugs

Under this project all proteomics-related equipment have been procured and installed. Latest models of MALDI ToF, LC-MS, GC-MS and various spectrophotometers have been procured and installed and standardized methods for biophysical analysis of therapeutic proteins such as recombinant erythropoetin, streptokinase, insulin, interferon, HepB vaccine etc. has been done by CCMB. Several companies are already making use of the expertise available in CCMB for biophysical analysis of their drugs (batches of drugs already in the market as well as those, which are under development) and testing for the presence of known and unknown impurities.

Infectious disease handling, storage and research facilities

The state-of-art BSL-3 facilities are being established at five different labs, which would be soon fully functional.

Drug development using *in silico* biology

- Development of a comparative genomics method to identify non active site
- Structural determinants of proteins as drug targets.
- Human micro RNA (miRNA) as a potential therapeutic for HIV infection.
- Identification of novel proteins in SARS using 'Gene Decipher' software .
- 5 new nontoxic targets predicted for Mycobacterium tuberculosis.
- Developed a novel method for human GPCR protein prediction in human genomes.
- Identification of potential candidate genes for Schizophrenia and Bipolar disorder using genetic information, pathway modeling and text mining software.
- Human Resource Development **:** (a) Over 180 bioinformatics professionals have been trained during the last five years, (b) Imparted training to over 250 post graduate students, (c) 80 students awarded post graduate diploma in bioinformatics (6 months course in collaboration with Edutech India).
- Several new softwares were conceptualized, designed, developed, used and also commercially licensed a part of this project during the current plan period. Most significant among them are:
    - PLHost^{FA} – A peptide library-based tool for function assignment of proteins;
    - COPS - comprehensive peptide signature database
    - GeneD'cfer – For finding and mapping genes
    - Proteome Calkulator - comparative proteomics and genomics
    - SEAPATH - Software for identifying virulence factors
    - ALPS - An Algorithm for Locating Proteases that are Secretory
    - TBPred - Prediction of outer membrane proteins
    - GPCRs - Classification of G-protein coupled receptors
    - mCOMP – Gene expression comparison and visualization
    - ArrayD - A general purpose software for Microarray design
    - ALiDS - Automated Ligand Docking Script
    - LigInt – Automated Evaluation of Ligand Interactions

Newer scientific herbal preparations for global positioning

Under this ambitious network project, 28 plants collected from identified place(s) at appropriate time and season from at least 2 different locations and commercial sources, duly authenticated on the basis of morphological and taxonomical characters have been identified. Initially based on the pre clinical data, four plants viz. *Withania somnifera, Phyllanthus emblica, Bacopa monnieri & Curcuma longa* have been identified and formulations are being prepared as positive health promoters for improving the quality of life of the aged and patients suffering from diseases such as cancer and diabetes. Based on the results of chemical and pharmacological profiling of extracts of the above four short listed plants, following three formulations as Positive Health Promoters (PHPs) have been designed for Anti aging, Anti-Cancer and Anti diabetics. Proof of efficacy studies would be carried out at two identified Clinical Research Organization i.e. Department of Clinical Pharmacology, Nair Hospital & TN Medical College, Parel, Mumbai and Ayurvedic Research Center, KEM Hospital & Seth GS Medical College, Parel, Mumbai, based on their core competence and track record to carryout the clinical trials. Agreement has been signed with Nicholas Piramal India Limited, Mumbai, to commercialize the final products at global level. Work on the multi dose level studies for anti-oxidant, immunomodulatory and adaptogenic activities for the above four plants are under progress to find out the effective ratio of the various constituents in the identified formulations.

Predictive medicine using repeat and single nucleotide polymorphisms

Under this network project validation of SNPs on 1700 samples belonging to 44 distinct endogamous populations has been completed. In the first phase, discovery of SNPs has been completed on 74 most highly prioritized genes based on their relevance to many complex diseases and pharmacogenomics. A total of 467 SNPs have been discovered representing all the major linguistic lineages and zones in the country. 950 non-overlapping genes have been identified and located based on their relevance to various complex and monogenic disorders. 63 populations have been identified from different large and isolated sub-populations of four major linguistic lineages that is Indo-European, Austro-Asiatic, Dravidian and Tibeto-Burman from different geographical zones that is North, South, East, West and Central. Entire mitochondrial genome has been analysed in these contrasting populations. Two genomic regions representing 140 SNPs i.e. 6 Mb region which could be potentially involved in schizophrenia and BPAD and 0.4 Mb gene involved in SCA12 has been analysed in 1695 samples.

Animal models and animal substitute technologies

This network programme has reported setting up of facilities for screening & testing of new drug entities for Yeast and Drosophila models for screening of anticancer drugs. Two hepatotoxicants have also been established in mouse model for detecting hepatotoxicity of the NCEs at levels lower than the doses which cause pathological changes.

1.6.11 HOUSING, ROAD & CONSTRUCTION

The Civil Engineering laboratories of CSIR, namely Structural Engineering Research Centre (SERC), Central Building Research Institute (CBRI), and Central Road Research Institute

(CRRI) took major initiatives in the form of network projects during the X Plan period to improve the quality and performance of building materials and construction including high performance concrete, utilisation of industrial wastes, health monitoring of special structures, high performance materials for road construction and development of analytical capabilities. Some of the notable achievements under the sector are given below:

Epoxy-cardinol IPN protective system for steel structures

CBRI has developed Epoxy-Cardinol IPN protective system for the protection of steel structures exposed to humid/saline environment having superior properties and corrosion protection efficiency as compared to other formulated coating systems.

Urethanized bitumen system for waterproofing of roofs

Conventional bitumen is brittle at low temperatures and fluid at high temperatures. CBRI has prepared urethanized bitumen with variable viscosity, adequate elastic resiliency and a reduced thermal susceptibility, as per the requirement of end use applications.

Self-compacting concrete (SCC)

SERC has developed the self-compacting concrete (SCC) mixture using locally available materials. SCC offers several advantages over conventional concrete, including easy placement and self-compaction as it freely flows through structural elements having complicated sections, around congested steel reinforcement and accessories while maintaining homogeneity and gets compacted without the need for any vibration.

Improved cement strength

NML has used mechanically activated Granulated Blast Furnace Slag (GBFS) in the range of 50 to 95% to replace clinker in Portland Slag cement (PSC) for improved cement strength. The strength of the sample containing 80-85% slag was comparable to the commercial cement (40% slag) used as a reference.

Developing new building construction materials

Developed processes to manufacture: (i) Phosphate bonded clay bricks. Process demonstrated at commercial plants (ii) Glazed building bricks and abrasion resistant ceramic tiles utilizing industrial solid wastes, (iii) Durable concrete and concrete composites, (iv) Luminescent Pigments (a new low temperature solid phase route to synthesis luminescent pigments, alkali earth metal aluminates, from metal nitrate precursors), (v) Coating system for concrete structures, (vi) Heat reflecting coating on flat glass for single to three layer system, (vii) Anticorrosive and anti-abrasive paint formulation based on copper tailing waste, (viii) Anti-algal coating, titanium dioxide dopes with oxides, for roofing tiles, (ix) Nickel-Phosphorous alloy coating for reinforcing bars, (x) Acrylic based wall putty, and (xi) Bituminous Poly-urethane net work based sealing compound (reaction of polyol with isocyanate in bitumen matrix).

The following products have been developed: (i) Natural fibre composite panels/door shutters using Jute/Sisal fibre in polymer matrix. Process know-how licensed. (ii) Cement bonded building boards/tiles using bagasse and pine needles. (iii) Multiphase plaster developed from waste gypsum for finish and base coat, (iv) Building boards using paddy husk and wheat straw etc. in polymer matrix (plastic wastes like PE bags, mineral water bottles, broken plastics) and (v) Jute reinforced polymer composite using fly ash and marble dust.

Design analysis and health assessment of special structures including bridges

Under this network project some scientifically attractive results were obtained, as under:

- Advanced analysis and design methods for steel framed structures
- Methodologies for system identification of buildings using ambient and forced vibrations technique
- Development of Model to predict corrosion rate of commonly used engineering metals in atmospheric and seawater environments.
- Methodology for rating of bridges using an integrated approach involving field measurements and analytical techniques
- Design for critical power plant components and of structures against natural hazards

New and improved road technologies

Under this network project some scientifically attractive results were obtained, as under:

- High performance materials for construction and repair of pavements: A few experimental stretches of different concrete specifications and with additive have been evaluated using various techniques.
- Materials for special road application: A new binder–porous bituminous concrete having excellent noise absorbing material has been developed beneficial for construction and maintenance of roads in hilly and desert areas.
- A state-of-the-art report on various noise absorbing materials has been prepared.

1.6.12 INFORMATION: TECHNOLOGY, RESOURCES & PRODUCTS

Strong demand over the past few years has placed India amongst the fastest-growing IT markets in the Asia-Pacific region. The Indian software and ITES industry has grown at a Compound Annual Growth Rate (CAGR) of 28 per cent during the last 5 years. The industry's contribution to the national GDP has risen from 1.2 per cent during the year 1999-2000 to a projected 4.8 per cent during 2005-06.

Recognizing great potential of IT, during 9th five year plan CSIR created IT sector as a separate thrust sector. It was in this plan period that URDIP was set up. Further, during 10th Five Year Plan NISCOM and INSDOC were merged in order to consolidate and effectively synergies their core competencies in IT sector.

CSIR laboratories viz, The National Institute of Science Communication And Information Resources (NISCAIR), New Delhi, is responsible for conceptualizing and operationalizing the three Network Projects, is the main contributor to the CSIR programme in S&T communication and information resources management. The National Institute of Science, Technology and Development Studies (NISTADS), New Delhi, is working in the domain of S&T information Dissemination & Products, serves as a bridge between Science and Technology on one hand and society and state on the other. Unit for R&D on Information Products (URDIP), Pune is working in the area of Phytoinformatics, Patinformatics, creation of subject specific databases web-enabled services through specialised portals content creation and software development. CSIR Centre for Mathematical Modelling and Computer Simulation (C-MMACS), Bangalore, is working extensively in the areas of weather (software development for fog forecasting, cyclone warning), environment modeling (prediction of forest fires), coastal monitoring (marine pollution) which require state-of-the-art IT infrastructure. Some of the notable achievements under the sector are:

Dissemination of information to S&T community

NISCAIR continued to provide a platform to the scientific community engaged in research in India and abroad through publication of 19 scholarly journals of international repute, covering all the major disciplines of science and technology. As a major achievement two of the NISCAIR journals, namely *Indian Journal of Traditional Knowledge (IJTK)* and *Medicinal and Aromatic Plants Abstracts (MAPA)* have been included in the coveted list of 'Prior Art Journals' used for prior art search before grant of patent(s) by the International Search Authorities. India is one of the 13 nations whose journals have been included in this list.

Science popularization

Popularization of science is one of the major activities undertaken by NISCAIR with the aim of creating public awareness on S&T issues while inculcating rational thinking and scientific temper among the people. Three popular science magazines continues to be published: *Science Reporter* (monthly) in English, *Vigyan Pragati* (monthly) in Hindi and *Science-ki-Duniya* (quarterly) in Urdu. Mainly targeted at general public and school children, *Science Reporter* and *Vigyan Pragati* enjoy great popularity throughout the country. During 2002-07 the circulation of *Science Reporter* and *Vigyan Pragati* showed an increase from 30,00 to 40,000 copies while that *Science-ki-Duniya* increased from 4500 to 9000.

Popular science books

NISCAIR publishes popular science and S&T books from time to time. Some of the books brought out during 2002-2007 are:

i. Healthcare, Education & IT for All
ii. Frontier science and Cutting-edge Technologies
iii. Science and Society in the 21st Century
iv. Health Technology as Fulcrum of Development for Nation
v. Revised and updated version of `Golden Treasury of Science & Technology'
vi. Tsunami
vii. Advances in Nanoscience & Nanotechnology
viii. CSIR Profile--2005
ix. The Hindi book entitled `Vigyan Aapki Seva Mein'

Information resources

Wealth of India Raw Materials, an encyclopedic publication describing the plant, animal and mineral resources of India, has been acclaimed as a reference standard for information on raw materials of India, particularly in the current global trend to incorporate traditional knowledge systems into the proprietary mainstream. *The Wealth of India* was cited as a source for revoking the US patent on turmeric.

Raw Materials Herbarium & Museum (RHMD)

NISCAIR has set up a Herbarium and Museum, assigned the acronym RHMD (Raw Materials Herbarium & Museum, Delhi), by the International Association for Plant Taxonomy, which appears in the publiication "Index Herbarium, New York, USA". The Herbarium houses over 6000 specimens of economic and medicinal plants of India and the Museum comprises over 2500 samples of crude-drugs, animal and mineral specimens.

IT facilities and programmes

Full Texts of 11 NISCAIR Journals are now available on NISCAIR website, http://www.niscair.res.in, which is being hosted on NISCAIR's own server. The issues from 2003 onwards are available on the website.

NISCAIR brought out a series of seven simple-to-use, practical books on various subject areas of IT in English. Some of these books have also been translated in nine Indian languages, viz. Hindi, Punjabi, Tamil, Kannada, Gujarati, Marathi, Bangla, Malayalam and Urdu, with a view to enhancing IT literacy among a much wider cross-section of the society. Already 65 of the 70 translated versions have been brought out and the rest are in various stages of processing. Over 55,000 copies of these books have already been sold.

Human resource development

NISCAIR has been offering an advanced master's degree level course in Documentation and Reprography known as Associateship in Information Science (AIS). NISCAIR has also been identified as the Programme Study Centre for the two IGNOU sponsored programmes namely: Master/Bachelor in Computer Applications (MCA/BCA) and Master/Bachelor in Library and Information Science (MLISc/BLISc)

SAARC Documentation Centre (SDC)

A Directory of Periodicals covering 2428 periodicals of SAARC Countries was compiled by SDC in 2005. The Centre has also acquired several new documents in core areas including reports of various international organizations.

The Centre has undertaken several training courses in the fields of Information and Information Management. It is currently engaged in the establishment of TKDL for SAARC nations.

Science policy and related studies

NISTADS undertakes studies specifically to generate novel research methods, to engender capacity building in analytics of policy sciences and to deepen skill sets on issues that are important to the country and to the domestic science institutions. NISTADS carried out the studies on (i) Indian industry & emerging high tech areas and (ii) S&T policy for rural India

Traditional knowledge and heritage database

URDIP has built Health Heritage, a database that incorporates both traditional knowledge from Sanskrit Classics referred to by practitioners of Indian systems of medicine and the modern information made available through systematic scientific research during the past forty years on medicinal plants used in Ayurveda. It has also developed databases on Ayuta Index, Metallopharmaceuticals and Enzyme Inhibitors.

PATESTATE – CSIR patent database

URDIP has converted patents granted to CSIR into an electronic format. It is a full-text database of Indian and Foreign patents granted to CSIR. A search engine has been incorporated for finding, exploring, analyzing and tracking patents and related information. The patents granted to CSIR during the period 1981 to 2000 were converted into a set of four CD-ROM. Abstracts of about 5000 patents granted to CSIR during 1942 to 2002 were also made available on a separate CD-ROM during CSIR Diamond Jubilee. All the available patents granted during 1961 to 1975 have been converted into electronic format.

A database of all the Indian Patents granted during 2001-05 along with their abstracts has been created.

Online IP marketplace

In order to facilitate the process of licensing and help laboratories to leverage full value of their intellectual property, URDIP has moved the abstracts of all the patents granted during last 56 years (i.e. 1940 to 2006) to an independent website

Marketing profiles have been created on the biotechnology inventions of CSIR that have been granted US patents. About 200 profiles are being made available on the patestate site. This site is planned to be linked to technology exchanges and patent/IPR websites and promoted worldwide.

Value added patent information services

URDIP so far has prepared about 30 Patent Analysis reports for the NIMTLI projects. It was decided to provide the value added patent information service to Indian industry. The response from industry has been encouraging. About half a dozen reports have been prepared and submitted to industrial customers. URDIP has also promoted this service with MNCs as they regularly conduct IP search and analysis for research and business planning. Two of the MNCs have qualified URDIP as potential supplier of service after multiple rounds of screening and selection procedures. URDIP has entered into yearly contract with one of the MNC to provide IP search and analysis services. Another multinational, after reviewing has given two pilot cases for IP search and analysis.

Patents on aromatics, medicinal and economic plants (PAMEP)-DBT

URDIP has done a complete IP search and analysis on 2000 widely used medicinal plants and has created a database of patents granted by patent offices all around the world on these plants. Database has 10,000+ patents.

Explorations – basic research portal

CSIR is the largest supporter of Doctoral research work in the country. URDIP in association with Human Resources Development Group (HRDG) of CSIR is creating a digital library of CSIR supported Ph.D Thesis.

Once the digital library is fully established at URDIP, it is proposed to work closely with all the major funding agencies in the country like DST, DBT, MIT, ICAR, ICMR etc. to extend the scope of digital library to cover all the reports of basic research projects funded by these agencies.

ANUSANDHAN- portal on science and technology

Anusandhan, (http://www.anusandhan.net/) Indian Science & Technology Portal being created by URDIP proposes to cover all branches of Science & Technology. Basically it will provide information on public and private S & T infrastructure, expertise and facilities available within these institutions, associated educational, government and private organizations and their activities, and related businesses dealing with hardware, software and services. The coverage includes 2500 publicly funded R&D institutions and 1500 privately funded centres.

The portal will be a single window showcase on Indian Science and Technology and is aimed at all the stakeholders in Indian Science and Technology.

Comprehensive traditional knowledge digital library (CTKDL)

Some of the significant achievements so far have been creation of the data on Traditional Medicinal formulations comprising 13 million A4 size pages of data on transcribed 62,000 formulations in Ayurveda; 60,000 formulations in Unani; and 1,300 formulations in Siddha. Other achievements include i) value addition to the database on medicinal plants for 500 species, ii) digitization of more than 50,000 herbarium specimens, iii) preparation of datasheets for 750 primary information and over 8,000 secondary information on Tribal Knowledge, iv) creation of five video films on Tribal Knowledge, v) preparation of TKRC on Traditional Foods and collection and entry of data on 70 traditional cuisines, and vi) preparation of TKRC on Traditional Architecture and construction Technologies and entry of 105 items in the data entry software.

In June 2006, through a Cabinet decision, CSIR has been made the custodian of India's traditional knowledge. Access to patent office of TKDL will now be controlled by CSIR.

National science digital library (NSDL)

A number of activities pertaining to this network project were carried out which focused on capacity building in terms of IT infrastructure required and planning for the project. These include completion of technical documents like Software Requirements Specification (SRS), Project Management Plan (PMP), Detailed Project Report (DPR), Request for Proposal (RFP), Software Quality Assurance Plan (SQAP), Design of the NSDL portal user interface and working shots as required on the portal. The bids for the NSDL Software have been technically and financially evaluated. Contents Creation for 65 e-books is in process and tender for establishment of Data Center is ready.

A Web based Content Creation Management System for NSDL has been developed for managing the contents created. eBook guidelines are being prepared. Sample e-content having learning objects is being developed for NSDL. Digital Asset Management Software Development tender has been floated and the work is likely to be awarded soon. Draft tender document has been prepared for IT Infrastructure and site preparation and non-IT infrastructure for setting up the state-of-art Data Centre.

Consortium access to electronic journals

This network project has concluded agreements with 11 international publishers and all CSIR labs are able to access 3300 journals.

The post agreement monitoring for all the above 11 publishers is going on. Usage statistics of 11 publishers are being regularly organized and loaded on search interface & monitoring system gateway so that user labs may see it.

Mathematical modeling and computer simulatios

- Base version of FINEART 3a developed and installed at all participating laboratories towards familiarisation of the software and release of theory, programming and user manuals
- Formulation, development, implementation and validation of efficient algorithms for non-linear explicit transient dynamic analysis of structural components (NONTRANS)
- Finite element based virtual casting module developed and successfully integrated with FINEART (FINECAST)
- Development of ground water model and its calibration (with NCEP data)
- Installation of meso-scale model for coastal processes and calibration of model for bathymetry data.
- Development of column model for atmospheric pollution using load data for Delhi and Mumbai.
- Data organization for active tracers
- Basic formulation of forest fire dynamics for Modelling of Forest Fire Hazard and Calibration of model parameter in terms of dry biomass.

1.6.13 LEATHER

The Indian leather industry occupies a place of prominence in Indian economy in view of its substantial export earnings, employment generation and growth potential. CSIR through its laboratory the Central Leather Research Institute (CLRI), Chennai has proven ability and core competence in leather science and technology to implement and spearhead major activities of relevance to the leather sector. The sectoral achievements are as under:

TDS control in leather processing

CLRI has pioneered in Total Dissolved Solids (TDS) reduction measures, which include effective desalting, hair saving, less sulfide -enzyme assisted unhairing, recycling of reliming liquor, recycling of pickle liquor. This has been implemented in two tannery clusters in Tamil Nadu viz. Dindigul and Pernambut. TDS reduction by 67%, chloride reduction by 40%, water (input) reduction by 15-20%, BOD reduction by 35% and reduction in sludge volume 20% has been feasible.

Zero discharge tanning

CLRI has developed a process for near zero discharge wastewater by enzyme aided washing and pickling wastewater. The wastewater discharge is 1litre /kg. This method has been tested at semi commercial scale in wet blue production and it has been found that the process does not render any negative effect on physical or organoleptic properties of leathers.

Non-zero discharge leather processing

CLRI has developed a three step tanning methodology towards near zero discharge leather processing. Cow hides are dehaired using standard enzyme based dehairing method. The hides are treated with α–amylase 1% and water 100% for 3 h in a drum. Alternatively, the hides can be treated with 0.9% sodium hydroxide and 350% water in a drum; duration of treatment is one day. A pickle–basification free chrome tanning at pH 5.0 has also been developed with and without masking.

Thermal insulation studies in garments

CLRI has studied thermal insulation property in garments by measuring the heat supply after bringing equilibrium between the environment temperature and heat source temperature. It was found that among all leather types (expect suede) the zipped garment has more thermal insulation than buttoned garments. Thermal insulation is found to be more in cow nappa apparels among the selected nappa and suede apparels. Based on the study, various types of leathers can be arranged in decreasing order of thermal insulation Fur (sheep-nappa) > Cow nappa > Goat nappa > Sheep nappa > Goat suede.

Evaluation of a new source of natural oil for possible use as a fat liquor

Jatropha oil is an indigenously available forest product from Madhya Pradesh and Andhra Pradesh. It is toxic and used, in a limited way, in native medicines and fungicides. It has a relatively high Iodine value (95-105) with Oleic and Linolic acid as major components (about 78%). CLRI has developed a novel method for complexing the oil with a polymer composition. It has proved to be successful. Pickled pelts treated with the product show tanning effect giving white and soft leather.

Enzymes in leather processing

Under CLRI-NCL collaborative programme on "Alkaline protease" supported by DBT, a fungal lipase from *Conidiobolus coronatus* has been found to be very good for dehairing and soaking of goat skins. Initially, an enzyme assisted process has been standardized using alkaline protease for dehairing of goat skins and cow / buffalo hides.

Utilization of chrome shavings for product development

The high protein content of chrome shavings has been utilized for reduction of chromium (VI) in the preparation of chrome tanning agent at CLRI. This approach has been exploited in the development of two products one with chrome shavings alone as reducing agent and other with equal proportion of chrome shavings and molasses. The developed products exhibit more masking due to the formation of intermediate organic oligo-peptides. Hence, the developed products find use as chrome tanning agents for leather processing, thus providing means for better utilization of chrome shaving wastes.

Technology package for synthetic tanning agents

New generation syntans namely formaldehyde-free chrome syntan and polymeric syntan have been developed by CLRI and patented for eco-benign chrome tanning in leather processing. The technology package has been licensed to M/s Balmer Lawrie & Co. These syntans are free from formaldehyde and also help in the reduction of pollution loads such as chromium and Total Dissolved Solids (TDS).

Cost effective therapeutic material

CLRI has developed a material based on starch / oil cake using water/vegetable oil as binder. It could be an alternative for existing methods of taking foot impressions of patients needing therapeutic and orthotic shoes. This new material provides additional advantages, such as forming the impression of foot in standing position, producing accurate negative impression of patient's insole and reusability. The clinical trials using the same were in progress.

Resolving the total dissolved solids problem

The tanning sector in India has been able to comply with Pollution Control Norms except for Total Dissolved Solids (TDS). Viable solutions for TDS have formed an area of priority. Pickle free chrome tanning based on use of combination of masking salts and polymeric syntan free from formaldehyde has been standardized at CLRI and field tested. Salt free short term curing methods have been developed and tested in goat upper leathers.

Ecofriendly processing

Hexavalent chromium formation poses serious problems in leather production. Post tanning chemicals/auxiliaries have been screened at CLRI for their tendency to convert Cr(III) to Cr(IV) in chrome tanned leathers. Suitable treatment methodologies have been developed using reducing agents to avoid formation of Cr(VI). The process technologies have been standardized for production of cow upper and sheep nappa garment leathers.

Biomaterial testing devices

CLRI has developed an instrument to study the two dimensional stress deformation (creep) effect in leathers. The two dimensional sample could be held in the sample holder and provision is given for simultaneous application of the load to the four pans attached to the sample holders, by releasing a lever. The strain gauge connects to the sample holders, by releasing a lever. The strain gauge connected to the sample holders records the deformation in four directions. The results obtained from the tests will be correlated, to understand the surface characteristics transformation as a function of the creep behaviour of leathers. The focus is on upper leathers only, as the results would have direct bearing on shoe uppers.

Standardization of technologies for bioresources for and from leather

Under this network programme bench scale processes for total of seven bioproducts for use in leather processing have been standardized and total of three collagen products have been commercialized for human health care applications and technologies of three enzyme formulations which can be commercialized for chemical assisted applications have been upscaled.

Environment friendly leather processing

The network project aims at reducing TDS load & Solid Waste Management. As per its mandate basket of technologies for reduction of TDS to <5000 ppm developed and demonstrated; some commercial tanneries have started adopting the technology systems. As a part of HRD mission on leather, about 300 people from ETPs and CETPs have been trained under private public partnership

1.6.14 METROLOGY

The National Physical Laboratory (NPL), New Delhi one of the earliest national laboratories set up under the aegis of Council of Scientific & Industrial Research has the responsibility of realizing the units of physical measurements based on the International System (SI units) under the subordinate legislations of weights & Measures Act 1956 (reissued in 1988 under the 1976 Act). NPL also has the statutory obligation to realize, establish, maintain, reproduce and update the national standards of measurement & calibration facilities for different parameters. Some notable achievements under the sector are:

New technological developments

- Electro-optic displacement sensors based on digital displacement and Moiré technique developed. The technique has potential applications in photolithography.
- A new data processing method using wavelet transform for online non-contact measurement of sieves and ring gauge using CCD camera developed.
- Development of standard platinum resistance thermometers (SPRTs) in the range -189 ˚C to 660 °C.
- Technology to design and fabricate Force Transfer Standards for measurement of force up to 500 kN with uncertainty of ± 0.04% (k=2) commercialized.

Standards

- Certified reference materials for N_2/air, pesticides, quartz, Li, Na, Ca, Mg, Zn, Cu and Fe metals in fuel and lubricants, alloy cast iron, sea water and gold geochemical standards.
- Primary Standard of Resistance based on the Integer Quantum Hall Effect has been established. The system comprises of a QHR device, cryostat with integrated superconducting magnet and a room temperature dc current comparator bridge.
- Established at a the Magnetic Standards Laboratory, NPL, a new Vibrating Sample Magnetometer (VSM) facility for the B-H loop measurement of a magnetic material at room temperature in the form of film, solid, powder or liquid. Measurement of magnetic moment can be done in the range of 10^{-5} emu to 10^{3} emu. This facility is now open for industries.
- Length measurement capability by interferometric measurement enhanced to 305 mm and by upto 1000 mm measurement uncertainty improved to 0.08 μm up to 305 mm and to 0.6 μm up to 1000 mm.
- High temperature blackbody established as primary standard of spectral radiance.
- Characterization of air-piston gauge primary vacuum standard (10kPa to 350 kPa).

Calibration

- Enhanced Apex calibration facilities in temperature, mass, force, ultrasonics, length and electrical parameters.
- Reestablished National Prototype Kilogram in 2002, re-calibration of 1 kg Transfer Standards with expanded uncertainty of 40 μg at k = 2.
- Key comparison in mass (APMP.M.M.K1) and in viscosity (CCM.V.K1) included in Appendix B of BIPM. NPL is coordinating APMP.M.M.K2 key-comparison in mass.
- Bilateral intercomparison of force standard machines between NPL(India) and PTB(Germany) in the static force range of 1 to 5 kN.

1.6.15 RURAL DEVELOPMENT

CSIR provides S&T based solutions for societal development through several of its constituent laboratories such as CBRI, CFTRI CGCRI, CIMAP, CLRI, CMERI, CRRI, CSMCRI, IHBT, RRL-Bhopal, RRL-Bhub. RRL-Jammu, RRL-Triv., RRL-Jorhat etc.. Some notable achievements under the sector are:

Food

Nutritious products from coconut sap

CFTRI has developed a process for the preparation of coconut sap concentrate from fresh coconut sap. The coconut sap, collected by tapping, was clarified, deodourised and concentrated.

Cost effective packaging system for a few traditional foods

CFTRI has carried out packaging and storage studies on *potarekhu, laddu*, in addition to chips of tapioca, banana and jackfruit. Moisture content - water activity relationships studies for *laddu* was studied to fix the critical moisture content. The container comprised an outer chromo paper/3-ply paperboard/kraft liner with aluminum foil and PVDC coating. It has maximum storage of 3 weeks.

Improving quality and storage stability of Neera

NCL has developed a laboratory scale membrane filtration technique for removal of bacteria. The shelf life of the packaged product can be extended to 10-15 days without affecting the stability, taste and nutrient profile of *Neera*.

Improved salt recovered from Sea/inland brines

CSMCRI imparted training to the marginal salt producers in South Gujarat and established a model salt works at Dharasana Village in Valsad District with the financial support from RTIG. Taking this as a model farm, the marginal Agarias were able to produce good quality industrial grade salt from sea brines, which was sold to user industries at a price much higher than that of the salts being sold prior to training.

Food processing

Some of the major technologies developed in the area of Food Processing are Clear lime-lemon flavour blend for soft drink manufacture; Honey based bakery products; Sugar free sweet bread; Flaking of fox-tail millet; Lentil chips; Dehulling of niger seeds; Fish wafers; Prawn wafers; Egg wafers; Pork wafers; Meat wafers; and Spirulina process with enriched iron content of high bio-availability.

Tiny scale domestic rice mill

To cater to the needs of the public and to assist them in the production of Completely Natural Nutrition Rich Rice, a tiny scale domestic rice mill has been developed and fabricated. The system comprises a feed hopper, rubber roll sheller, husk aspirator, cyclone collector for husk, friction polisher all mounted on a common frame. Provision to adjust the gap between the rubber rolls to regulate the dehusking percentage is also made. It is also possible to regulate the polish imparted to the rice grains by adjusting the weight on the polisher load arm.

Water

Ceramic membrane based technology for removal of arsenic and iron from contaminated ground water

CGCRI has developed a ceramic membrane based technology for simultaneous removal of arsenic and iron from highly contaminated ground water. The process developed removes arsenic down to < 10 ppb - the level specified by WHO and iron content below 0.1 ppm (WHO specification is < 0.3 ppm). A pilot plant was installed at Akrampur, Barasat, West Bengal in collaboration with Public Health Engineering Directorate (PHED), Govt. of West Bengal where ground water containing arsenic 0.9 - 1.3 ppm and iron 5-12 ppm is being treated successfully to produce safe drinking water conforming to the WHO specifications. About 500 litres of safe drinking water is being produced daily and distributed to the local inhabitants.

Electrochemical technology for the removal of arsenic from drinking water

CECRI has used the electrochemical process for the removal of arsenic, which consists of an electrochemical cell. An electrochemical cell that is capable of reducing the arsenic concentration in drinking water from 3 ppm to 0.05 ppm with current efficiency of 95% is available for demonstration.

Prototype RO plants for long-term field study

CSMCRI installed two RO plants of 2000 liters/hour capacity, one each at Kalyanpur village of Bhavnagar district, Gujarat and Kasari village of Jhunjunu district, Rajasthan. The pilot plant in Gujarat is operating with 10,000 ppm brackish water to give about 600 ppm water with 94% salt rejection. The pilot plant installed in Rajasthan is treating brackish water of about 2200 ppm TDS to give a potable drinking water of about 250 ppm TDS with 90% selectivity.

Development of solar powered R.O. unit

Two solar powered R.O. units of 8 l/hr and 15 l/h capacity were designed and fabricated on behalf of Rajiv Gandhi National Drinking Water Mission (RGNDWM). One unit was installed at Science Park, Jaipur for publicizing and promoting the concept while the second unit was installed for conducting field trials in Bahadurvas village of Jhunjunu District, Rajasthan. Both the units are operating with the help of two solar photovoltaic (PV) panels.

Animal powered RO for brackish water desalination for village community

CSMCRI has developed a unique water desalination system, which uses animal energy to energize the high-pressure pump to effect brackish water desalting by R.O. process. The above system can produce 300-500 liters/hr product water from feed water whose TDS is in the range of 3000-5000 ppm.

Iron removal plant

CMERI has developed a system which removes iron from water containing ferrous salt by oxidation accompanied by the dissolved oxygen introduced into the water through aeration and precipitating the iron as ferric salt, followed by setting, filtration to remove precipitates.

Essential oils

Biovillages: geranium as catalyst of green hope

CIMAP has demonstrated the cultivation of geranium in Kumaon region of Uttaranchal. Installation of distillation units and harvesting of the crop for distillation was also done. Three distillation units were designed, fabricated, installed and commissioned, one each at the geranium bio-village sites, i.e., Someshwar, Dangoli and Gagrigol in Uttaranchal to facilitate the distillation of the crop produced in the respective bio-villages.

Cultivation of aromatic plants and production of essential oil

RRL Jorhat has successfully propagated oil extraction technologies for aromatic plants such as citronella grass, lemon grass and patchouli. These activities have generated employment avenues for more than twenty thousand families in rural and hilly areas of North East India. Today, more than 450 MT of citronella oil and related products are being produced using RRL Jorhat technologies.

Agro processing technologies in oils and spices

RRL-Trivandrum has transferred the technologies for processing of Fresh Ginger to make Ginger oil/Ginger Powder, Red Palmolein (50 TPD) and Zero Trans shortening Technology on Refining of Rice Bran Oil of 50 TPD

Solar distillation system for extraction of essential oils for aromatic plant materials

RRL-Bhubaneswar has designed and developed the solar still of the distillation system, which is of green house type capable of accumulating heat energy through appropriate mirror arrangements.

Ma Shakti (STEP) project on cultivation and utilization of aromatic herbal farming

The project aims at imparting training to 10,000 women on cultivation and utilization of aromatic grasses for income and employment generation. RRL, Jammu is providing technical guidance and consultancy services to the project sanctioned by Dept. of Women and Child Development, Ministry of Human Resources Development, Govt. of India and is being implemented through an NGO, J&K Ex-services League. RRL, Jammu imparted training and 15 demonstrations were given in the field to the beneficiaries in different blocks of Jammu district. Planting material of 47 lakh slips to cover 500 hectares is also supplied. Four distillation units are set up in the field and assisted the NGO in selling 490 liters of essential oil worth of Rs. 2 lakh.

Ceramics

Lead-free Jaipur blue pottery

CGCRI has developed body composition, engobe and matching glaze totally free from lead and other toxic ingredients present in the raw materials used for making traditional Jaipur blue pottery. It has opened up greater export potential by way of elimination of lead in the product and achieving greater cost-effectiveness. The technology has been transferred to Rural Non-Farm Development Agency (RUDA), Jaipur for disseminating the same to the blue pottery artisans of Jaipur and several other regions of Rajasthan.

Sustainable ceramic clusters development in the state of Gujarat

In order to ensure survival of small and medium ceramic manufacturers against the steep competition owing to globalisation in the domestic and international market, CGCRI initiated progammes on cluster development. The programme for modernisation of Indian ceramic industry, vastly dominated by small and medium enterprises (SMEs), includes (a) consideration of the prevailing socio-economic conditions and making use of the vast resources of low grade raw materials by way of its upgradation/beneficiation; (b) Optimum use of the indigenously available equipment and machinery and the available large skilled/unskilled labour force in the country and (c) utilisation of indigenous technology and know-how. 418 ceramic units of Thangadh, Morbi-Wankaner, Himatnagar and Ahmedabad of Gujarat have been remarkably benefited in their productions with the able guidance of CGCRI by way of implementation of appropriate technologies developed at the Institute for these SMES.

S&T for employment generation for women

In order to promote employment generation among women Self Help Groups (SHGs), CECRI has adopted 'Perungondan Viduthy Village Panchayat' at Pudukkottai District, Tamil Nadu. A cashewnut processing industry is being set up.

Medicinal plants

Kalam- A new lemongrass for drought prone areas

A hardy drought tolerant strain CPK-F_2-38 rich in citral has been developed through hybridization and rigorous screening of the F_2 recombinants of *Cymbopogan pendulus* and *C.khasianus* hybrid. The variety has been named "Kalam" after the name of His Excellency Bharat Ratna Dr. A. P. J. Abdul Kalam. Its performance was evaluated in both irrigated and rainfed areas. The crop is perennial and lasts for five years. The returns of variety 'Kalam' is two and a half times higher than the traditional crops grown in drought prone areas. However, it gives three times higher yield under irrigated conditions and compares favourably well with the existing varieties.

Tawi Rosa – A new variety of cymbopogon developed for drought prone areas

RRL Jammu developed a hardy drought tolerant strain RLJ-CCI for rainfed areas named as "Tawi Rosa". The main feature of this strain is that it can withstand moisture stress level of 15% and contains total alcohol in the range of 80-85%, calculated as geraniol 70-75% and geranyl acetate 10-15%. Apart from the main chemical constituents, it contains 3-5% ocimene which is used in high grade perfumery. Under rainfed conditions, this variety in 1st year has a capacity to produce 20 -25 tonnes of fresh herb yielding 80 -85 kg of essential oil. In subsequent years it produces 35-40 tonnes of fresh herbage yielding 150-160 kg /ha essential oil. Essential oil content varies from 0.35 to 0.45% depending upon the harvesting seasons.

Raft cultivation of eucheuma

CSMCRI has successfully adopted raft cultivation of Eucheuma, which has greatly boosted the yield of the seaweed. Farmers are being advised to switch over to this mode of cultivation to increase the returns from cultivation.

Technology for plant growth promoting *trichoderma*

NBRI has developed a technology for mass production of *Trichoderma* based biopesticide by using solid state fermentation. The *Trichoderma*-based bio-pesticides have been found to control soil borne diseases of economically important crops viz. betel vine, chickpea maize, sunflower, mustard, gladiolus etc. Novel plant growth promoting microorganism (*Pseudomonas* and *Bacillus* and *Trichoderma* strains) based products, were also developed which have the ability to control phyto-pathogenic fungi, promote plant growth, tolerance for abiotic stresses, and solubilize phosphate even under abiotic stress conditions. The products are useful as plant growth enhancer and bio-fungicide for seed, soil, and foliar applications.

Housing

Urethanized bitumen system for waterproofing of roofs

Conventional bitumen is brittle at low temperatures and fluid at high temperatures. CBRI has prepared urethanized bitumen with variable viscosity, adequate elastic resiliency and a reduced thermal susceptibility. The urethane bituminous system has been prepared as per the requirement of end use applications.

Natural fibre composite door shutters

CBRI fabricated water resistant composites from surface sisal/jute modified fibres and unsaturated polyester resin. These composite laminates meet IS:12406-88 in terms of physico-mechanical properties and performance characteristics. Composite door shutters are prepared by bonding the jute/sisal laminates face with plastics wood slab core. These door shutters conform IS: 4020-98 and exhibit superior performance as experienced in the existing alternatives for conventional doors.

Solid toughened paper board

RRL-Jorhat has developed specialty board with high physical strength properties imparting special characters like wet strength, resistant to water, oil, fire and grease. This type of solid boards can be used for making cartons and other packaging for scientific storage of food grains, tea, food products, vegetables and fruits, etc. apart from using it for packaging of heavy and sophisticated machine parts.

Agro machinery

Automatic compact model of pulse thresher-cum-winnower

RRL-Bhubaneshwar has developed an automatic compact model of pulse thresher-cum-winnower. This is a small machine, which threshes & winnows in one go of the crops of different pulses such as green gram, black gram, arhar, horse gram, lentil etc. irrespective of shape & size of plants and grains. It crushes the crop residue into small sizes during threshing, which is suitable for animal feed.

Mini tractor

CMERI has also developed a 10 HP mini tractor " Krishi Shakti" for farming in small fields.

Sabai grass yarn making machine

CMERI has developed Sabai Grass Yarn Making Machine which is used for producing spun yarn from Sabai grass and many other natural fibres i.e. wild grass, munj, jute, coir etc. With Button Hole Attachment developed by CMERI the machine can be used on various woven & knitted fabrics like silk, cotton and polyesters.

Pedal pump

CMERI has developed a Portable and low cost Pedal pump to lift water from ponds up to a head of 2 meters. It can irrigate about 2000 m^2. of land in eight hours and does not require power. Instead of draught power, self weight of the operator is used for pumping operation.

1.6.16 WATER: RESOURCES & TECHNOLOGY

CSIR laboratories viz, National Chemical Laboratory, Pune, Central Salt & Marine Chemical Research Institute, Bhavnagar, National Environmental Engineering Research Institute, Nagpur are working in R&D areas of safe drinking water. Besides other laboratories viz, National Geophysical Research Institute, Hyderabad, National Institute of Oceanography, Goa and Central Glass & Ceramic Research Institute, Kolkata are also working on water related issues. Some of the notable achievement under the sector are:

Preparation of alumina membrane for micro and ultra - filtration

NML has designed and prepared a very thin disc type ceramic membrane (0.3-0.8 mm thickness, 25-30 mm diameter) made of pure alumina. It is suitable for micro-filtration applications. A sol coating was applied to the disc to form an ultra-filtration membrane. Water permeability through the membrane under suction and under positive pressure is comparable with that of ceramic membranes prepared by conventional methods. A very sharp drop in the pore size distribution pattern around 0.4 μm indicates that no pores larger than this exist. This implies that all particles with radius > 0.4 μm are trapped in the membrane, providing excellent separation efficiency. Results of microbial separation tests confirmed the possibility of micro-organism separation through these membranes.

Groundwater sanctuary

Studies have been carried out by NGRI in low rainfall, groundwater overdraft hard rock granite terrain of Gurukanipalli Watershed, Chittoor District, A.P. These efforts have resulted in evolving groundwater sanctuary in the waste land part of catchment area for meeting the water requirement of problem villages. The village water supply has been commissioned under gravity and siphoning without depending on energy.

Ceramic membrane based technology for removal of arsenic and iron from contaminated ground water

CGCRI has developed a ceramic membrane based technology for simultaneous removal of arsenic and iron from highly contaminated ground water. The process developed removes arsenic down to < 10 ppb - the level specified by WHO and iron content below 0.1 ppm (WHO specification is < 0.3 ppm). A pilot plant was installed at Akrampur, Barasat, West

Bengal in collaboration with Public Health Engineering Directorate (PHED), Govt. of West Bengal where ground water containing arsenic 0.9 - 1.3 ppm and iron 5-12 ppm is being treated successfully to produce safe drinking water conforming to the WHO specifications. About 500 litres of safe drinking water is being produced daily and distributed to the local inhabitants.

Desalination by Reverse Osmosis

Prototype RO plants for long-term field study

Under the DST sponsored project, CSMCRI installed two RO plants of 2000 liters/hour capacity, one each at Kalyanpur village of Bhavnagar District, Gujarat and Kasari village of Jhunjunu District, Rajasthan. The plant has six spiral elements each of 4” dia x 1m size made from our TFC membranes. The pilot plant in Gujarat is operating with 10,000 ppm brackish water to give about 600 ppm water with 94% salt rejection. The pilot plant installed in Rajasthan is treating brackish water of about 2200 ppm TDS to give a potable drinking water of about 250 ppm TDS with 90% selectivity.

Development of Solar Powered R.O. unit

Two solar powered R.O. units of 8 l/hr and 15 l/hr capacity were designed and fabricated on behalf of Rajiv Gandhi National Drinking Water Mission (RGNDWM). One unit was installed at Science Park, Jaipur for publicizing and promoting the concept while the second unit was installed for conducting field trials in Bahadurvas village of Jhunjunu district, Rajasthan. Both the units are operating with the help of two solar photovoltaic (PV) panels.

Animal powered R.O. for brackish water desalination for village community

CSMCRI has developed a unique water desalination system, which uses animal energy to energize the high-pressure pump to effect brackish water desalting by R.O. process. The desalination system, which runs on animal power, consists of speed increaser, high-pressure pump and membrane modules. The above system can produce 300-500 liters/hr product water from feed water whose TDS is in the range of 3000-5000 ppm.

Pesticide removal unit for producing potable water free from organic pollutants

NEERI has developed a unit for producing potable water free from organic pollutants viz., ϒ-HCH, p,p'-DDT and p,p'-DDD and p,p' - DDE, total coliforms, faecal coliforms, turbidity and total organic carbon (TOC). The unit is tap attachable and has the capacity to store treated water, consumes no electricity and is easy to operate and cost-effective.

1 Million litres/day RO plant

CSMCRI has commissioned a one million litre per day desalination plant based on RO technique for treatment of tertiary treated sewage water at the Chennai Petroleum Corporation Ltd. (CPCL), Chennai, in November 2003. Data on plant performance indicate that feed water is of salinity around 2000 ppm and 75% of the water is recovered in permeate.

Electrodes for desalination of brackish water

CECRI has developed an electrode suitable for desalination of brackish water by electrodialysis with periodic current reversal. The electrode withstands periodic current reversal - half of the time, it has to function as anode and rest of the time it has to act as cathode. Very few electrodes are capable of performing this dual role. These electrodes have a valve metal substrate activated by a noble metal based coating. Accelerated life testing in an artificial desalination set up predicts over 10,000 current reversals without any potential escalation.

Arsenic and Iron removal from ground water by ceramic microfiltration membrane

CGCRI has developed microfiltration system, which is a novel approach for decontamination of arsenic and iron from groundwater and to cater to the need of safe drinking water for community use. The basic components of this hybrid system are i) absorption of arsenic by the colloidal media particles suspended in water and ii) application of membrane based separation technique for solid liquid separation using ceramic microfiltration membrane module. The salient features of the technology are simultaneous removal of arsenic and iron from highly contaminated groundwater below the limits recommended by WHO; Modular design with flexible production capacity; and Semi-automatic user friendly operating procedure. This technology has been transferred to many Small Scale Industries for mass production.

Low cost adsorbents for removal of arsenic from contaminated drinking water

ITRC has developed iron-coated sand for decontamination of water spiked with 50 ppb Arsenic. This material was reused for five consecutive days. The efficiency of Arsenic removal on day one was maximum (90-95%) which declined to 80% on day three and 60 % on day five. The technique can be utilized for water decontamination upto 50 ppb Arsenic level. The materials required are not very costly. Iron coated sand once prepared can be used for three days.

1.7 NATIONAL S&T HUMAN RESOURCE DEVELOPMENT

CSIR is playing a pivotal role in creating, maintaining and replenishing the pool of trained human resource which has helped to generate a sizeable core of S&T manpower in the country. Various research institutions, academia and industry tap this pool to meet their need of trained S&T manpower. CSIR's support for National S&T Human Resource Development extends from the age of 16 to 65 years and transcends diverse sectors and disciplines. It has a mandate to develop and nurture S&T manpower at the national level. It also promotes guides and co-ordinates scientific & industrial research through scientific projects at the national level. The activities under the Scheme include: award of Shanti Swarup Bhatnagar Prizes (SSB) and CSIR Young Scientist Awards (YSA); selection of Junior Research Fellows (JRF) through National Eligibility Test (NET); selection of Senior Research Fellows (SRF), SRF Extended Research Associates (RA), Senior Research Associates (SRA); funding of Extra Mural Research (EMR); schemes at universities/ R&D organizations; Visiting Associateship Scheme; Travel / Conference / Symposium grants; Emeritus Scientist(ES) Scheme.

CSIR provides financial assistance to promote research work in the fields of Science & Technology, including Agriculture, Engineering and Medicine. The assistance is provided by way of grants to Professors/Experts in the universities. IITs, post-graduate institutions, recognised R&D laboratories, both in public and private sectors. Research proposals of applied nature, as well as those falling under basic sciences, which attempt to solve specific problems being pursued by CSIR laboratories, or in newer and complementary fields, are considered for CSIR support. Priority is given to multi-disciplinary projects which involve inter-organisational co-operation (including that of CSIR laboratories). Preference is given to schemes which have relevance to research programmes of CSIR laboratories. Basically programmes under 2 categories of Research Schemes namely, General Schemes and Sponsored Schemes are supported. Under General Schemes**,** funds were provided to for one or more Junior Research Fellows (JRF), Senior Research Fellows (SRF) and Research Associates (RA), contingencies and equipment. Sponsored Schemes were essentially to supplement or complement the research programmes of the CSIR Laboratory. During the Tenth Plan 838, 59, and 114 projects were sanctioned under Research and Sponsored Scheme and Emeritus Scientist Scheme.

Achievements in the Tenth Five Year Plan

The National Eligibility Test (NET) for Junior Research Fellowships has made a mark in India. It has come to be recognized as an examination of highest standards and integrity. During the 10th plan, the scope of NET was further extended by introducing Shyama Prasad Mukherjee (SPM) Fellowship Scheme to identify and nurture budding young scientific talent. During the Xth Plan period, 3976 JRFs(NET qualified), 1842 Senior Research Fellows, 419 Research Associates, 264 Senior Research Associates (Under Scientist's Pool Scheme), and 30 Shyama Prasad Mukherjee Fellows were supported in different disciplines till 31st March, 2006. Travel Grant was recommended to 953 Research Scholars for attending international conferences abroad and 1921 Symposium Grants were provided to scientific societies, institutions, university departments to promote scientific temper & interaction among scientists. Forty Six (46) meritorious scientists were recognized with the prestigious Shanti Swarup Bhatnagar prizes for their outstanding research contributions done primarily in India, and 19 CSIR Scientists were given Young Scientist Awards to promote in-house excellence, during the same period.

The Technological Entrepreneurship support to research scholar's scheme has been introduced to inculcate the spirit of technological entrepreneurship in CSIR research scholars. About 120 students from various CSIR labs have attended this programme till date. Through Tran Disciplinary Fellowship scheme, an effort is being made to support students to work in specialized niche areas where boundaries between disciplines are transcended and knowledge and perspectives from different disciplines are integrated. A maximum of 25 fellowships can be given each year. Though CSIR schemes mostly catered to post-graduate and PhD students, CSIR enlarged upon the science support base by initiating CSIR Programme on Youth for Leadership in Science to attract the best school students towards science through a unique hand holding experience. It aims at encouraging youth to discover science as an exciting, rewarding and fulfilling career. Every year about 1000 students are being benefited from this unique experience. Under the Scheme "Faculty training and motivation and adoption of schools and colleges by CSIR labs" each CSIR laboratory has been entrusted to adopt at least one school and one college in its sphere of influence to promote interest, excitement and excellence in science education. This new scheme is also an endeavor to take up training and motivation programmes for selected science teachers. During 2006-07 about 24 labs availed this scheme. A new HRD initiative "CSIR Diamond Jubilee Research Interns Award Scheme" was announced by Hon'ble Minister for Science and Technology on the occasion of Diamond Jubilee Celebrations of CSIR on 26th September 2002. It is a preparative scheme through which young interns shall be trained in the tools and techniques of research under supervision of experienced scientists in CSIR. The scheme has taken off in 2003-2004. About 250 research interns are being trained each year in different CSIR laboratories.

1.8 INTELLECTUAL PROPERTY & TECHNOLOGY MANAGEMENT

CSIR since its very inception had set up an in-house Patent Cell to deal with IP matters. The main responsibilities of the Cell were confined to obtaining patent protection for the inventions developed in the CSIR laboratories. However, with India becoming TRIPs compliant the situation demanded the professional management of Intellectual Property (IP) as a valuable resource. This Cell was christened as the Intellectual Property Management Division (IPMD) and its mandate extended to cover intellectual property rights in all its forms i.e. patents, trade marks, design, copyrights, plant patents, plant varieties, software patents, etc. Also CSIR declared its IP Policy in 1996 and became one of the first entity in the country to frame and adopt such a policy.

The management of the IP in all its diverse aspects was initiated as a planned activity from the Ninth Plan under a scheme titled Intellectual Property & Technology Management. The implementation of the Policy and the associated scheme has resulted in enhanced international patenting activity and also a paradigm shift in the R&D activities of CSIR. Further, with India's joining the Patent Cooperation Treaty (PCT) in 1998, CSIR has been increasingly using PCT mechanism as a strategy for international filing of patent applications. CSIR is today the leading (among the top three) entity among all developing countries in PCT filings. Thus at the end of NFYP CSIR applications had in its portfolio 658 Indian patents and 342 Foreign patents, with another 1800 patent applications at various stages of examination and consideration by different Patent Offices.

Achievements in the Tenth Five Year Plan

At the commencement of the Tenth Five Year Plan (TFYP) CSIR emerged on the international IP scene as an entity to be reckoned with and proposed an Intellectual Property & Technology Management (IPTM) scheme. The Scheme was for in-house purposes and objective was to basically seeks to capture, secure, enhance and realize the value from the Intellectual Property of CSIR. The total outlay for the scheme was Rs 145.15 crore of which Rs. 100.00 crore was to met through the plan budgetary support to CSIR and Rs. 45.15 crore from earnings of CSIR laboratories (LRF).

CSIR Patenting Activity

A brief outline of the CSIR patenting activity since from 1997 to 2006 is given in the following table. During the Tenth Five Year Plan 1649 Indian patents were filed and 893 were granted, similarly 2511 patents were filed abroad among which 860 were granted. The figures given below represent the filing activity upto 31st March 2006.

YEAR	INDIA		ABROAD	
	Filed	Granted	Filed	Granted
1997-1998	264	155	94	28
1998-1999	310	134	114	48
1999-2000	377	112	208	47
2000-2001	408	117	490	62
2001-2002	413	341	569	89
2002-2003	421	166	771	189
2003-2004	406	276	566	217
2004-2005	415	175	529	275
2005-2006	407	276	645	179
TOTAL	3421	1752	3986	1134
TOTAL FILED:	**7407**	**TOTAL GRANTED:**	**2886**	

IP Licensing

Licensing of IP from publicly funded organisations remains a challenging problem the world over. Proactively, CSIR has systematically made efforts for the realization of value from its IP portfolio. These initiatives would help to partner with licensing firms abroad to leverage CSIR's intellectual property internationally to form research collaborations, business partnerships and licensing deals. CSIR has also acquired software tools for surveillance to check infringement of its IP rights. A table below indicates that out of total 172 licensed IPs in various areas, about 41% inventions have been licensed in the area of chemical sciences, followed by about 35 % in the areas of drugs and pharmaceuticals, 5% in the area of inventions related to food and about 15 % in the area of Engineering like devices and remaining 4 % in other areas. The percentage utilization of CSIR's inventions is of the order of 5.7 % which is above the average rate elsewhere in the world. The money realized by CSIR for licensing of its IP during 2000-05 is of the order of Rs.18.5 crore.

CSIR's licensed IP Portfolio

Area	No. of patents licensed	%
Drugs/Pharmaceuticals/Bio	61	35.46
Chemical	70	40.70
Food	8	4.65
Engineering	26	15.12
Others	7	4.07
Total	172	100

Monies realized by CSIR from licensing of its IP

(Rs. Crore)

Year	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005
Earnings	2.69	3.09	4.23	4.37	4.08

1.9 R&D MANAGEMENT SUPPORT

The various functional units/divisions located in CSIR Headquarters provide the R&D Management support to the national laboratories through the Scheme. The Headquarter is the focal point of the organization and catalyses and facilitates the laboratories by establishing, equipping and realising excellence in R&D, promoting brand equity, financial self-sufficiency, global competitiveness and disseminating organizational learning. It provides support to the laboratories for human resources development, international scientific collaboration, publicity and public relations, performance appraisal, scientific audit etc. It is the link between the laboratories, the government, the parliament and international agencies.

Objectives

- Promote a professional and holistic human resource management in CSIR by offering training programmes for development/enhancement of functional & personal competencies/skills;
- Identifying areas needing reforms in the overall personnel policies of CSIR;
- Creating focused group of human resource development both at the Centre and in each laboratory;
- Network with professional HRD organizations, both within India and outside and bring "best practices" to CSIR;
- To scout & pinpoint international scientific collaborations that could synergise and add value to R&D activities in the National Laboratories;
- To establish CSIR brand equity among general public as a scientific organization of relevance through multimedia & print; and
- To catalyse and mobilize packaging of information products based on CSIR databases and developments.

Achievements during the Tenth Five Year Plan

Some of the contributions from under the scheme during the Tenth Five year Plan are summarized as below:

During the Plan the Central Management Support has established Human Resource Development Centre for organizing and conducting of induction, orientation, refresher and skill up-gradation training programmes for different categories of CSIR staff. The Centre thus conducted one-day interactive familiarization programs in 32 laboratories including CSIR Hqrs. for familiarization of new format for Annual Review of Performance (APR) for Group IV scientists. In order to bring improvement in quality & transparency in working , the Centre organized awareness-cum-implementation programme on ISO 9001: 2000 QMS certification for HOD's, senior scientists, administration & finance personnel from Hqrs and laboratories. The Centre is carrying out various other activities such as development of Management Information Systems (MIS) for its various HR activities, Training Need Analysis (TNA), Creation of focused HRD groups in labs., Computer Based Training (e-training) etc. The Centre has so far conducted more than 120 training/inductions/orientation or refresher programmes.

A new organ called the Performance Appraisal Boards (PABs) was introduced to critically review the performance of each laboratory once in every three years. The first performance review was completed prior to the launching of Tenth Five Year plan.

CSIR constituted a Committee under the Chairmanship of Dr.Vijay Kelkar, Adviser to Finance Minister in June 2003 to assess and value the socio-economic-environmental benefits arising from CSIR's R&D outcomes and S&T activities. The Committee has made several far reaching recommendations to enhance the value of CSIR's contributions.

International collaboration especially in R&D on cutting edge technologies has become very important to keep pace with expanding frontiers of knowledge. Major growth in knowledge and technological trade has often inculcated sustained multi-national efforts and we have begun to realize that international collaboration can no longer be relegated as an annexure to our research portfolio. During the Tenth Plan, CSIR's international programmes had a clear focus on joint collaborative projects rather than on exchange programmes, as was the case in previous plans. These projects were implemented by a large number of scientific groups in collaboration with their partners in institutions with which CSIR had specific arrangements. Some of the collaborative projects in which CSIR scientists participated were supported by various inter-governmental and inter-academy cooperative arrangements such as those of DST, DBT and INSA. Under the Plan period, major technical assistance came from EU, French and Norwegian sources. CSIR labs received external funding for 45 projects amounting to $50 million for setting up facilities in areas of high priority.

The Unit for R&D in Information Products created to catalyze and mobilize packaging of information products based on CSIR databases. A new web based information service – technology advisory point (TAP) – that acts as a gateway to scientific knowledge for small and medium enterprises (SMEs) launched. The service is in a pilot phase, initially covering areas in chemicals, food and leather technology. In the Tenth Plan efforts were made to establish CSIR brand equity through multi media and print world.

1.10 NEW MILLENIUM INDIAN TECHNOLOGY LEADERSHIP INITIATIVE

CSIR operates New Millennium Indian Technology Leadership Initiative (NMITLI) which has emerged as a unique initiative of the government, carving out a niche in the innovation space. It enjoys an unprecedented brand image and is looked upon as a role model in the domain of public-private-partnership initiatives launched by a federal government. The projects cover diverse areas ranging from liquid crystals to decentralized power packs; mesoscale modeling to nano-material catalysts; microbiological conversions to biotech molecules; functionalisation of alkane to advanced nano-materials and composites; defunctionalisation of carbohydrates to biodegradable plastics; novel expression systems to medical implants; novel office computing platform to low cost horizontal axis wind turbine; and new targets and markers for cancer to advanced drug delivery systems.

Some of the achievements under NMITLI include:

1.10.1 TB therapeutics

New molecule: Worldwide approximately two billion people are infected with *M. tuberculosis*. Nearly, 8 million new cases are added annually and the biggest burden is in South East Asia. Around 3 million deaths due to tuberculosis are reported every year with India accounting for a substantial percentage. With the rampant Human Immunodeficiency Virus (HIV), TB disease is acquiring the severity of epidemic proportions and kills one in three people co-infected with HIV/AIDS. Furthermore, TB is a major barrier to economic development, costing India over Rs. 12,000 crore a year.

Under the NMITLI programme, the expertise of 12 institutional partners and an industry were synergized for the development of new targets, drug delivery systems, bio enhancers and therapeutics. Significant success has been achieved under the project. A new pharmacophore has been developed for the treatment of tuberculosis. The molecule works through combination therapy (compatible with the present drugs), is less toxic, clears the total infection within two months and no recurrence has been observed. It fits well into the present four-drug therapy by replacing one or two drugs from the (present) cocktail. This is the first success achieved in developing new tuberculosis therapeutic in the last 40 years globally. An IND application for the molecule has been cleared. Presently it is under phase-I clinical trials. In addition, some new drug targets have also been developed.

Drug delivery system: A novel drug delivery system based on dry powder inhalation of micro particles containing rifampicin / rifabutin and isoniazid has been developed. Inhalation of these micro particles containing anti-TB drugs can clear *M. tuberculosis* from the lungs in a shorter period of time as compared to oral administration alone. IND directed studies are in progress.

1.10.2 Oral herbal formulation for the treatment of psoriasis

Psoriasis is one of the most common dermatological diseases affecting around 2% of the world population. It is a chronic inflammatory skin disorder with most common areas of involvement being the joints like elbows, knees, gluteal cleft and scalp. Its cause and pathogenesis are not clearly understood. Most importantly no preventive/curative therapy exists for psoriasis except the symptomatic management.

Based on the traditional knowledge and using the reverse pharmacology approach, the development of a single plant based oral herbal formulation was initiated under NMITLI for making it globally acceptable. Extensive studies comprising finger printing, activity guided fractionation, efficacy studies, toxicology, safety pharmacology, pharmacokinetics and toxicokinetics enabled the filing of an Investigational New Drug (IND) application for the first time in the country for a herbal based compound. Currently the formulation is in phase II clinical studies .

The estimated market for psoriasis therapeutics is around US$ 4 billion and the development, once completed, will enable India to capture a significant part of the market.

1.10.3.Lysostaphin - A novel biotherapeutic molecule for *staphylococcus* infections

The rise in resistance to current antibiotic treatment has made the standard treatment for *Staphylococcus aureus* infection less reliable. Lysostaphin, a 27-kDa-glycylglycine endopeptidase produced by *Staphylococcus simulans*, with its rapid and unique mechanism of action of cleaving the penta-glycine bridges linking the peptidoglycans in their cell wall, has the potential to substitute and /or augment antibiotics as the first line of treatment for *S. aureus* infections. The development of pure recombinant lysostaphin, free from pre-pro lysostaphin, under NMITLI Programme has provided an opportunity to assess its efficacy against drug resistant *Staphylococcus aureas* infections. The industry partner in the project holds a product patent for pure recombinant lysostaphin in 126 countries. The only other product patent is for pre-pro lysostaphin held by AMBI, USA. IND directed studies viz., chemistry, manufacturing, control, efficacy, stability, safety pharmacology and toxicology have established its efficacy and safety. The IND application filed for Lysostaphin has been cleared and clinical trials are about to begin.

Globally there is demand for effective drug for hospital acquired infection and Lysostaphin will be positioning itself in the top of the brand in the global market. This provides an excellent opportunity to the industry partner to emerge as a global player in developing recombinant Lysostaphin formulation for treatment of Staphylococcal infection.

1.10.4.Softwares for bioinformatics

With its strengths in both Information Technology (IT) and Biotechnology (BT), India is set to play a leading role in the biological revolution through Bio-informatics. However, its growth in the country had been hampered by the high cost of imported software. Thus need was felt for the development of indigenous, affordable and at the same time globally competitive software packages.

NMITLI took the lead and catalyzed and supported development of such softwares to be commercially available globally in consonance with its philosophy of positioning India as leader in the Bioinformatics area. Some softwares have already been launched. These include:

A. BioSuite: Distinctive knowledge segments from both academia and industry were brought together as ‘Team India’ to develop the versatile, portable software package that is unparalleled anywhere. The industry partner spearheaded the development with the assistance and support of 18 institutional partners.

The developed software package works as a multipurpose tool for carrying out diverse bioanalyses. It comprises of eight modules viz. genome analysis, comparative genomics, sequence analysis, structural analysis, 3-D modeling, simulations, structural manipulation and drug design. The software conforms to the CMM5 level and has several unique features, which are not present in similar other packages that are available in the market at exorbitant cost. Unlike the other available softwares, which are confined to specific machines, BioSuite is portable in the sense of being able to run on a variety of platforms, ranging from very high-end servers to clusters of low-end machines, including clusters of heterogeneous computers. This software is globally competitive, and affordable to the Indian community. In the second phase, the industry partner has developed BioSuite C, the cluster version of the BioSuite.

In March 2006, NASSCOM recognized BioSuite among the best IT innovations in India.

B. GenoCluster: The software package includes a number of stand-alone software tools namely, Gene 'D'cfer, Proteome calkulator and Seapath. Brief details of these are as follows:

Gene 'D' cfer: gene prediction software to determine gene candidates among all possible ORF's of a given DNA sequence by using a peptide library and an artificial neural network.

Proteome calkulator: a powerful computational application developed for complete genome sequence analysis of model organism. It allows simultaneous study of several genomes by performing set theory operations like union, intersection, difference and inverse. The characteristic feature of the tool is that it carries out multiple analyses on a wide range of bacterial strains.

Seapath: a unique software tool specially designed for the prediction of virulent proteins. It focuses on identifying adhesins or adhesin like proteins from newly sequenced genomes. It is capable of identifying potential targets (bacterial and viral surface antigens/adhesin) for new vaccine formulations and developing therapeutics against drug-resistant pathogens.

C. '*Darshee*': A PC based high-end 3D visualization platform for computational biology has been developed for visualization of complex bioprocesses. The back end has been coded in C++, the user interface in JAVA and the scripting engine in Python. This architecture has the feature that it is multi platform and runs on Linux, Mac and Windows platforms. In addition, visualization modules have been developed along with an extensible framework BIML (Bioinformatics Mark-up Language) for representing biological data, to be validated by *Darshee*.

The final structure of Darshee has been packaged within the family of Avadis products. Further, the technology has been integrated into the Array Assist suite of tools marketed by Stratagene, one of the world's leading distributors of life science products.

Avadis received the Frost & Sullivan Award for excellence in technology in 2005.

1.10.5. Developments in Information Technology

***A. SofComp* and Mobilis:**

NMITLI has catalyzed development of a low cost embedded computing platform to replace conventional PCs for day-to-day office work. Three variants of *SofComp* devices have been developed and were launched by Hon'ble Minister of State for Science and Technology. *SofComp* is designed to be deployed in multiple applications in small offices and businesses and help proliferate the deployment of IT solutions in India. The device has a small set of canned applications for easy use and maintenance.

It has low power consumption and is operable with poor quality mains power supply and during extended periods of power failure. With a battery back up of 7-8 hours, it is well suited for rural Indian conditions where power breakdown is a frequent feature. It can also be customized for deployment in field areas.

These unique products are targeted at competitive prices ranging from Rs. 7,500/- for the basic model to Rs. 10,000/- to 18,000/- for the *Mobilis* variants depending on the sales volume.

B. Refining and strengthening monsoon and weather prediction based on mesoscale modeling:

Modelling and forecasting of rains and extreme weather events, particularly in the tropics are extremely important and equally difficult. For a country like India, their success is of paramount importance because of overbearing impact on the social and economic effects on large population. Further, monsoon events are extremely critical for Indian economy.

The science of monsoons is complex and requires multidisciplinary approach to tackle the problem. The current Indian practice and capability in monsoon prediction involves either the use of empirical models to make macro-level predictions, or the use of synoptic general circulation models, or using imported regional codes (software) - which are often optimized to work best only in the mid latitude regions. In order to overcome this deficiency, a project on Mesoscale modelling of monsoon related predictions was initiated under the NMITLI programme. With the development of an integrated hardware/software system (named the NMITLI Platform) for accurate weather prediction over the tropical regions, the concept of more reliable weather forecasting at mesoscale level for tropics has been demonstrated. A powerful 128-Processor supercomputer has been developed based on dual Pentium boards and using the in-house developed communication devices customized for meteorological applications. It has been tested and is presently operational at National Aerospace Laboratories (NAL), Bangalore. Further, a new software model named, Varsha 1.0 code (the new GCM code) has also been developed. A near linear speedup (97 on 128 processors) was obtained for the new code, which is creditable for a spectral GCM.

1.10.6.Plant Biotechnology

A. New varieties

Mentha: Two new varieties of *Mentha piperita* namely, 'CIM-Indus' (with the characteristic of high menthofuran and pulegone) and 'CIM-Madhuras' (with the characteristic of sweet smell) have been developed. CIM-Indus' has an oil profile, which expresses differentially at different stage of growth. In the variety, menthol and menthofuran content have been desirably optimized.

CIM-Madhuras' is a unique variety with an enhanced oil yield of about 22.6%. The varieties have been released for commercial exploitation.

Ashwagandha: *Withania somnifera* (Ashwagandha) is used in more than 200 ayurvedic, siddha, unani and other herbal formulations in India, indicated as antiarthritic, anticancer, immunomodulatory, aphrodisiac, diuretic, restorative and rejuvenative. However, systematic collection of the germplasm had never been attempted in consonance with pharmocological studies.

Under a NMITLI project effort was made to collect the Ashwagandha germplasm, which resulted into collection of 150 independent accessions from various geographical locations, with many of them having contrasting chemotypes. The occurrence of C_{20} $^{-}$OH containing molecules, including withanolide A, withanolide E and withanolide D has been established from these accessions. Efforts are on to explore the pharmacological activities of selected chemotypes and individual molecule to identify the best chemotype for adaptogenic activity which could then be passed on to the farmers for commercial cultivation.

B. Gene expression vectors:

An artificially designed synthetic promoter, bi-directional and two – element dependent novel gene expression vectors have been developed for high level expression in plants. The vectors express at levels about 100 fold higher than the CaMV35S promoter. The two-element dependent novel system could be used for developing a reversible male sterility and restorer system for hybrid seed production. One patent has been awarded on the chemically synthesized artificial promoter. Two PCT applications have been filed on the bidirectional and the two-element promoter system.

1.10.7. Biotechnology for leather: towards a cleaner processing

The making of leather is an age-old process. World over leather is made employing technologies which involve processing of skin or hide using large amounts of industrial chemicals and a wide variety of specialty chemical formulations. A large number of the processes involve ‘do-undo’ operations resulting in severe environmental pollution. The world is compelled to follow this highly polluting ‘Chemical Route’ in the absence of any alternative. This was a great challenge before the scientific community. Under the NMITLI programme, a paradigm shift has been brought about in beamhouse operations in leather manufacturing through bioprocessing as opposed to the currently used chemical processes.

World-class leads have been obtained for an environmentally friendly bioprocessing route for ambient preservation of skin/hide, enzyme only dehairing and defleshing. (Specific technology packages for the (Fig.9) above are being developed with the user industry for commercialization. The development is poised to change globally the face of a highly polluting industry forever.

1.10.8. Semi-Commercial Plants

Lactic acid from Sugarcane: A laboratory scale process has been developed for the production of highly pure lactic acid from sugarcane juice. The impurity profile of the lactic acid produced matches with the Purac H-90 grade lactic acid, which has been used for preparation of PLA. The process development involved developing a mutant strain of *Lactobacillus delbrueckii* MAC 168701, use of sugarcane juice as raw material, selection of a hydrolysable nitrogen source, optimization for fermentation conditions at 10L and 100L scale, evolving a suitable downstream processing route, purification using HPLC and conditions established for polylactic acid (PLA) preparation from a standardized polymer grade lactic acid produced through the above process. A 300 TPA pilot plant is being established at a commercial location for the production of lactic acid, based on laboratory scale data generated in the ongoing project.

Cellulose ester from bagasse: The feasibility of fractionating bagasse into cellulose (93 $\pm$ 2% α - cellulose content, 67% yield), hemicellulose (80% yield), and lignin (80% yield) has been established by steam-explosion technique. Cellulose triacetate synthesis was established from cellulose so fractionated. This would be used to develop biodegradable polymer. Further, the process for sodium lignosulfonate synthesis was developed and tested for its suitability in cement applications in comparison with the imported sample of lignosulfonate. The synthesized lignosulfonate was found to be suitable for application as cement additive. The process is being up-scaled and validated at pilot plant (100 kg) scale.

From the foregoing, the Tenth Plan period by far has been the best period for CSIR in terms of recorded achievements. Highest number of highly cited research publications, patents, a basket full of technologies and lead molecules, ever increasing earnings, annual contribution of about 500 highly trained young Ph.Ds to augment India's research capabilities; increasing research collaborations/tieup with discerning large Indian & multinationals – all speak of CSIR's as the top S&T organisation of the country.

Tenth Five Year Plan has so far been the best, we have plans to make the Eleventh better than the best.

CHAPTER - II

APPROACH AND STRATEGY FOR THE ELEVENTH FIVE YEAR PLAN

2.1 INTRODUCTION

India's centralized planning process is governed by seven cardinal policy objectives: growth; social justice & equity; modernization; self-reliance; food; productivity and employment. These would continue to be the guiding principles for the Eleventh Plan (2007-12) which commences from 1st April, 2007.

A very large part of our planning is concerned with fiscal aspects and physical targets. It must, however, be recognized that it is the human and natural resources, scientific methods and technologies which are the fundamental elements in the creation of wealth for higher productivity, increased efficiency and completely new ways of doing things. The Eleventh Plan, therefore, would place emphasis on these components which have received inadequate attention in the past. Eleventh Plan would be the vehicle that would position the country to be a super power- economically, strategically and scientifically. For the Eleventh Five Year Plan the Government of India is envisaging the economy to grow at an annual growth rate of 8.5%%. This implies that Agricultural Sector will have to grow at a rate of 3.9%, industry at 9.9%, services at 9.4%, and exports at 16.%, while keeping the imports at a level of 12.1%. The implicit growth of manufacturing sector which is a subset of industry is targeted for 12%. The above growth rates interwoven with each other, of course, would depend upon many factors. Some of these factors are internal to the Indian economy and some are influenced by the external environment. The growth in the agricultural productivity can be sustained on a long term basis only through continuous technological progress and this calls for well structured strategies for research & development. Industrial sector has gained a lot over the past decade or so due to liberalization and is gradually integrating with the world economy. Some of the sub-sectors like automobiles, pharmaceuticals, biotechnology products, speciality chemicals, textiles have acquired unprecedented level of global competitiveness and need to be supported to maintain the present edge. The Eleventh Plan is also placing special emphasis on infrastructure and skill development, the two crucial and critical catalysts for growth.

The services sector is currently the fastest growing sector of economy accounting for about 54% of GDP. It is estimated that this sector has the potential for creating 40 millions jobs and generating additional $ 200 billion annual income by 2020. In the Eleventh Plan, the government is placing special focus on this sector so that its potential to create employment as growth parameter is fully realised.

Along with high growth rate aiming for improving livelihood support and increasing employment, the Eleventh Plan strategy calls for new emphasis on education, health and other socially relevant issues. The approach to the plan by the Planning Commission has very appropriately reflected in its title "Towards Faster & More Inclusive Growth". The importance of S&T in the development process envisages innovative solutions.

Eleventh Plan is being formulated at a crucial juncture. In a unipolar and truly globalized world where trade barriers are getting dismantled, an organization has to perform and deliver in real time. The global competition is real and severe for every sector including R&D organizations like CSIR. Either we stay relevant by increased and defined focus with well set and articulated delivery protocols or be swamped by competition, primarily from private sector, R&D laboratories both national and international.

This document presents a road-map for a renewed, revamped and relevant CSIR.

2.2 ELEVENTH PLAN FORMULATION

The Planning Commission has constituted 'Steering Committee on Science & Technology' under the Chairmanship of Dr. R. Chidambaram, PSA to GOI. It has constituted a Working Group for CSIR with Dr. R. A. Mashelkar, DG, CSIR as its Chairman vide its notification of 8th May 2006 to formulate strategy and approach for the Eleventh Plan and develop therefrom programmes/projects to be implemented through its existing vast competencies **(Annexure 1).** The Working Group of CSIR had further constituted 16 Sectoral Groups and 4 Thematic Groups to help it to assess in greater details the specifics and R&D needs of the sectors & themes. The composition and TOR of the Sectoral Groups and Thematic Groups is appended in **(Annexure 2)**.

The 16 Sectoral groups were setup on Aerospace Science & Engineering; Agro, Food Processing & Nutrition Technology; Biology & Biotechnology; Chemical Science & Technology; Earth system science; Ecology & Environment; Energy : Resources & Technology; Electronics, Photonics & Instrumentation; Engineering Materials, Mining/Minerals & Manufacturing Technology; Pharmaceutical, Healthcare & Drugs; Housing, Road & Construction; Information: Technology, Resources & Products; Leather; Metrology; Rural Development; Water: Resources & Technology. The 4 thematic groups looked into the need for programmes on Human Resource Development, Intellectual Property Management & breaking IP barriers, International collaboration in Cutting edge technologies and Public Private Partnership and enabling industries.

These groups representing diverse domain expertise from academia, industry, user departments and agencies, scientists and technologists and policy makers held several meetings. The groups reviewed the performance of CSIR in the immediate past, undertook sector specific SWOT analysis and drew up perspective plans based upon opportunities. These groups also identified emerging areas and programmes there from and suggested the financial and other resources for the Eleventh Plan. It is estimated that more than 1250 mandays of expert time has been utilized for the formulation of the Eleventh Plan.

Besides the aforementioned, CSIR also sought inputs from the young scientists of its laboratories/institutes, and five year plan proposals from the laboratories. Further the policy directions received, time to time, from CSIR Society, CSIR Governing Body, the Performance Appraisal Boards, Kelkar Committee have also been taken on board in the formulation of the Eleventh Plan. The approach adopted by the Planning Commission for S&T is the backbone of efforts in the XI Plan.

2.3 THE APPROACH

The World is changing and constantly setting new challenges for R&D organizations. With the shortening of innovation cycle and ever shifting economic climate, established methods are getting swept aside and the old working paradigms are no longer effective. At present, it is universally accepted that knowledge has taken the centre stage and is driving the economic growth, social development and job creation and is the primary source of competitiveness in the world market. This knowledge engine resembles like a biological system with a huge synergistic network of veins and arteries – mutually supporting and dependent on each other.

A dynamic organization like CSIR has to make a shift to such culture - working and delivering through network and partnership mode. At the same time, it has also to provide opportunity to all partners to grow. This would be the central theme of CSIR of tomorrow.

India of the last decade, has moved away from resource and labour based economy towards a knowledge-based economy as reflected by a visible change in patterns of economic and social activities that are taking place. The pace of globalization is impacting Indian economy and R&D arena. A number of contract research organizations (CROs) have came up in the country and have captured significant R&D contracts from abroad and are providing efficient R&D and services to offshore locations. Several multinational companies have setup R&D units and are providing employment opportunity to the talented young researchers, an alternate away from not so well paid government jobs and in the wake creating a crisis of talent for set-ups like CSIR.

By and large, CSIR laboratories have responded in adequate measures to the changing national and international S&T, economic, trade and intellectual property and related developments. During the last decade, CSIR has transformed itself into a formidable organization and has been able to meet the challenges posed by changing environment. CSIR realizes it well that innovation is today the key driver to long term economic growth, competitiveness and instruments for many of the societal challenges. Therefore, CSIR today, is recognized as organization par excellence, performance driven and user focused. It is referred as a model of how countries can harness their top quality scientific research institutions to the task of industrial technology development, innovation and global competitiveness.

It is essential for CSIR and important for the country that it continues to be as relevant as it was in the past, but even more so in the future particularly during the period of Eleventh Plan and beyond. It may have to bring in many more reforms to be front runner R&D organization globally.

The guiding beacon for CSIR during the Eleventh Plan would continue to be its mission Statement which is to provide "Scientific industrial research and development that maximizes the economic, environmental and societal benefits to the people of India".

CSIR would continue to foster the organization values of:

(i)	Excellence in Science	Science that will lead and not follow
(ii)	Global competitiveness	In technology based on high science, rooted wherever feasible in India's rich heritage of knowledge
(iii)	Local relevance	Finding holistic and optimal solutions to the pressing problems of the country by deploying technologies, ranging from the simplest to the most sophisticated often disruptive, suited to socio-cultural, economic ethos of the people; and
(iv)	Innovation	In all sphere of activities ranging from science, technology, management and financing.

CSIR's Eleventh Plan approach would be focused on "technology led accelerated inclusive growth". The approach to the plan would be three pronged:

- First is to conceptualize, plan and work, in network mode, on R&D of relevance both nationally and globally – and to align it with public, private, strategic or social needs as the case may be. There would be a strong paradigmatic link between network and PPP modes.
- Second is to forge viable, defined and scientifically challenging R&D projects in Supra institutional mode to make each laboratory a cohesive and close knit unit; much away from thinly spread and diffused units of the past. This would help align and reinforce the core competency of the lab.
- Third is to build within each lab Centres of Sustainable Growth, a kind of magnet to attract Scientists/Technologists of Indian origin, a large number of trainees, industry-both national and foreign, and above all help create a Think Tank to look at the future with a clear vision and shape that into a mandate.

2.4 STRATEGY

Guided by the above approach, CSIR's operating strategy would be to think globally, plan nationally and act locally. CSIR recognizes the importance of benefits that its laboratories must deliver to the Nation in return of the Government budgetary grant, i.e Benefit to Cost where benefits reflect on effectiveness and costs reflect on efficiency. In the Eleventh Plan CSIR has put emphasis on maximizing the Benefit to Cost ratio of goods.

In order to do so the laboratories that are in the knowledge (research) intensive areas, would have to benchmark and compete globally, and would need to position themselves strategically by 'doing the right things' and also attain high levels of operating efficiency to be competitive. The laboratories that deliver strategic and public outputs, and so unique in themselves that the nation cannot do without them, would have to explore alternate managerial practice for select activities to further enhance their usefulness and 'efficiency of operation'. The laboratories which deal with service specific socio-economic sectors would have to concentrate on providing front-end research to industry and act as technology reservoir positioning strategically all activities to continue to be relevant to the industry.

2.4.1 Core operative strategy

Thus during the Eleventh Plan, CSIR laboratories shall seek to enhance the leverage of their unique scientific and technological capabilities to attain goals working through:

- Supra-institutional project wherein the laboratory will have at least one flagship project in which the majority of the groups within the laboratory participate. This would synergise the in-house capabilities to optimize the outputs.
- Inter-laboratory network mode, as initiated in X Plan. In the Eleventh Plan, these networks will be further strengthened with a sharp focus to develop products/processes and knowledge which is of interest to the nation.
- Network mode, with institutions/agencies outside CSIR to develop advanced technologies/products/prototypes/knowledge base that require multi disciplinary inputs and synergies.
- Offering and augmenting existing facilities as national facilities in R&D service mode to other academic and R&D institutions to help maximize their outputs and build synergies with them. In the Eleventh Plan, few major national facilities will be created in frontier

areas to help in generation of competitive knowledge capabilities at par with international standards of future relevance.

- The emerging areas in each sector and building projects around them to generate competency. This will help India to secure global leadership position.

These are more specifically addressed as:

(i) Supra Institutional Projects

Each laboratory will have balanced portfolio of projects in the ‘knowledge-market, space. Keeping in view its R&D domain, it would formulate at least one overarching programme drawing strength and participation from a majority of the groups within the laboratory. This would be termed as Supra-Institutional project.

(ii) Network Projects

CSIR has endeavoured to carve out a niche for itself by working through network projects in the Tenth Plan. The emphasis has been laid on networking on expertise, resources and facilities so that the project would target substantial increase in value of inputs of Science & Technology in knowledge driven areas. In the Eleventh Plan, experience drawn from the Xth Plan has emboldened CSIR to launch yet another set of network projects of multi disciplinary nature. The output of network projects is expected to bring in a new direction and also generate new areas of business for CSIR.

(iii) Inter - agency Projects

The present day process of knowledge generation and diffusion is characterized by a shift from research based stand alone scientific disciplines to trans-disciplinary and inter - institutional networking. CSIR would synergise with academia, industry and Government to build World Class facilities and identify, niche areas where CSIR as a part of 'Team India' can make a major impact.

Further CSIR, due to its vast and wide exposure to science and technology, nationally and globally, is well placed to build strategic partnerships at diverse levels. Its efforts to forge a Global Research Alliance, with international agencies of repute, to address global problems through global funding is one such endeavour. CSIR shall identify opportunities for strategic partnerships for large inter-organisational impact making projects. CSIR would also involve and associate the 'Indian research community' in these partnerships as a 'Team India' endeavour; and would also involve international scientific community for such programmes and projects. These would be undertaken as Inter Agency projects.

(iv) Facilities

CSIR would consciously develop and sustain select laboratories to maintain internationally competitive knowledge generation capabilities in key technology areas and will build World Class facilities.

(v) Creating, nurturing and sustaining the core knowledge frontier

CSIR recognizes the role of continuously enhancing core competencies of its establishments in basic and applied research through appropriate blue sky projects. These are a means of building a national knowledge base and an expression of national culture in which knowledge is valued and the search for new knowledge is appreciated. It would support such endeavor in its laboratories/institutes.

(vi) Projects in public private partnership mode

NMITLI has created a brand image and is viewed today as a benchmark of PPP schemes. It has shown a new way of managing the R&D projects, appropriate to Indian conditions. As India is entering into a new era of R&D, more such newer approaches of innovation development would be evolved and experimented.

(vii) Development of R&D Human Capital

In the Eleventh Plan, some of the select CSIR laboratories, that have consistently achieved excellence would be helped to take on the role of affiliated Research centres under the deemed to be university status. Other laboratories would also be encouraged and facilitated to forge symbiotic, seamless linkages and partnerships with institutions for higher learning by sharing with them their facilities, human resources (faculty) and infrastructure to develop specialized human resources in transdisciplinary niche areas and later on to become part of the deemed University.

Over the years a large number of scientists have superannuated in CSIR and new recruitments have not taken place. In the process it has become an aging organization. This needs to be corrected in the Eleventh Five Year Plan by fresh induction of manpower, primarily in the scientific and technical cadres. In addition it is also proposed to create mechanism for hiring temporary scientific & technical manpower for implementation of R&D programmes to overcome the problems posed by ageing and shortage of manpower.

2.4.2 New Initiatives

Centres of excellence

CSIR's operational domain extends to almost all niche areas of Science & Technology. Its recognized strength being in the areas of Chemical, Biological, Materials, Engineering, Leather, Energy sectors to name a few important ones. In addition, CSIR has been at the forefront, rather at the top, amongst all national institution in technology generation and dissemination in various areas of its mandate. Over the years, this all has given it a global recognition wherein its contributions both in basic as well as applied areas have placed it in the higher echelons of performance driven apex scientific bodies.

It is appropriate now that we institutionalize a process wherein a systematized study on Indian R&D contributions in general and CSIR contributions in particular in the aforesaid areas are documented, critically analyzed, lessons drawn and use the resultant R&D indicators for S&T policy formulation. To facilitate that, it is proposed to institute 6 Chairs of Excellence, one each in the areas of Chemical Sciences, Biological Sciences, Material Sciences, Leather, Engineering and Physics, and S&T Planning. These Chairs would be located in CSIR institutions and occupied by Scientists/Technologists of eminence to be selected through a process of invitation and or nomination. Such incumbents would be provided honorarium and contingencies commensurate to the expectations – which are indeed high - to work. The incumbents could also chose to work on related theoretical aspect of R&D area specific to the Chair.

Centres for sustainable growth

CSIR plans to create a core thematic group built around a central theme to attract Scientists and Technologists of Indian origin to work, in some of the performing laboratories on short duration basis, in R&D areas of national relevance and global opportunity. These Centres, which would act as centres for sustaining growth of the laboratory and would also induct students to work on cutting edge research projects.

Early Stage Venture Fund(ESVF)

In India there is a lack of support for the early stage funding for the new products, process or technology to go in to the market. The entrepreneurs are not coming forward to commercialize the new products and processes developed in the research institutions particularly in public funded institutions. As a result many new products and processes will remain in the shelf and become obsolete over time. Hence there is a need of encouraging new entrants who could build sufficient credibility so that they can go for commercial production. To help those entrepreneurs who can come forward to commercialize and market the products and process developed by CSIR a ESVE is proposed in the Eleventh plan.

CSIR-University R&D centres for excellence

India has well developed higher education system which has served us well so far but in the present global scenario there is a need of quality and trained manpower in the field of science & technology. The higher education institutions are finding it difficult to get quality manpower to carry out R&D in science and technology resulting in huge gap between the demand and supply. Unless we provide quality manpower in S&T we will run in to skill constraints which will limit our ability to exploit this important area of competitive advantage. To augment this CSIR is proposing CSIR-University R&D centres for excellence where universities would have access to state-of-art infrastructure and expertise available in various CSIR laboratories to enable universities to generate quality manpower in frontier areas of S&T.

Best project management practices

The Eleventh Plan projects calls for professional management due to their complexities, working on mutlti-disciplinary and trans disciplinary areas, networking within and outside CSIR i.e large number of partners, optimum utilization of resources and time delivery of the outputs. In order to enhance the level of productivity and optimize on the return from investment and in a transparent manner in tune with higher level of performance standards, CSIR proposes to adopt international standards of project management. Several management and ERP tools would be used for managing the Eleventh Five Year projects A vigorous review with the help of modern project management practices will ensure envisaged outputs and outcomes are achieved in the given time frame. A third party outcome audit system would be introduced for internal alert and for mid-course corrections.

Scale up and Validation of leads developed in-house

CSIR at its various constituent laboratories has developed promising leads that require scale up/validation. This is more true for the areas of Drugs & Pharmaceuticals, Chemicals and Biotechnology where several leads/targets have been identified / developed under various projects under Tenth Plan. In addition, a few more are expected to be generated during the Eleventh Plan period and they may even extend to the areas of Electronics, Materials and Minerals. However, many of these cannot reach industry since they have not been scaled up/validated with due diligence, at scales acceptable to industry for undertaking appropriate techno-commercial level. Pharmaceutical industry on its part, has strengths in product development, large scale production and marketing and depends on R&D institutions mainly for: a) specialized knowledge base and skill-sets to supplement their R&D – Pathway analyses, protein engineering, drug designing, molecular modeling, designing novel experimentation, computational analyses, etc., b) generation and screening of libraries of potential compounds c) contract manufacturing and d) preclinical studies with an ultimate objective to have validated/screened targets that could be taken on commercial scale for economic benefit. Target-validation technologies are, thus, in strong demand and are the most critical challenge facing large pharmaceutical companies world over.

CSIR proposes to initiate focused activity in the areas of validation and scale up. First, this would enable CSIR to take the leads/targets it has developed to the next stage and develop a strong pipeline of potential compounds/libraries. Second, with this set up it could effectively partner with industry to address some of their issues that need advanced R&D interventions. This would provide platform for linking CSIR's knowledgebase to economic and social benefits. Third, it would provide on the job training to create a pool of trained scientists/lab resources. These activities by themselves would lead to innovation and help position CSIR in global R&D space

Open source drug discovery programme for infectious disease

The discovery and development of drugs by pharmaceutical companies are driven by market size and price. Such companies do not wish to invest huge money in discovering drugs for such disease conditions which do not give them the commensurate market size and price. Diseases of the third world, particularly the infectious diseases, therefore do not fall under their immediate research priority. The prohibitive cost of IPR protection and maintenance, and confidentiality of drug development which does not allow collective efforts of the best brains of the world available in National Laboratories and Academic Institutions to work together with industries. However, the remarkable success of the open source movement in IT Sector like development of Linux operating system and World Wide Web has given enormous benefit to the developing world. The remarkable success of open source movement in IT sector gives confidence to the potential success of such a movement in healthcare sector.

In the Eleventh Plan it is proposed that CSIR would set up programmes for open source drug discovery through national and international collaborations involving National Laboratories and Academia. "Open Source Drug Discovery Movement" is a new concept and has major advantage of reducing the cost of development by bringing like-minded scientists with complementary diverse skill set together under a single umbrella.

CSIR's reach for Rural development

CSIR has developed baskets of techniques, processes and technologies that can be used to provide services and product to the masses. It is proposed to focus on this aspect and reach masses through NGO's, Educational institutions and State Government Agencies and at the same time continue to add to this national priority during the Eleventh Plan.

CSIR for North East development

CSIR has a basket of techniques and technologies of value to the North-East sector. These would be deployed for better use of local resources, employment generation, upgradation of artisan skills and improvement in quality of life. CSIR, during the Eleventh Plan, will involve developmental agencies as the vehicle for propagation in defusing this knowledge to a large section of the society. This is expected to result in a long-term rewarding partnership to accelerate S&T base development of the region.

2.5 MONITORING

The activities through programme/projects would be continuously monitored. The outcomes would be measured keeping in mind the objectives of the programme by following appropriate methodology. The monitoring would be undertaken at three levels, the project management level, sectoral management level and the organizational level. Performance Appraisal at the organizational level on a periodic basis would also be effected and input, output and outcome indicators would be developed for all the sectors. In the key areas of development projects international expertise would be made use to maximize the benefits. These would be benchmarked with the best available in the contemporary organizations.

CHAPTER-3

ELEVENTH FIVE YEAR PLAN PROGRAMMES & ACTIVITIES

3.1 INTRODUCTION

The bold and the daring approach proposed for the XI Plan by the Planning Commission to achieve new vistas of growth, is expected to provide enough opportunities to convert growth potential of 8.5% into reality. This however calls for a total departure from the past practices in developmental planning and implementation, by working out new management strategies involving coordination and stronger linkages for more effective implementation.

India is poised for a massive upturn in economic and social growth. It is also on a path to becoming a technology driven superpower in the coming years. For India to derive maximum growth centric advantage through S&T, its science technology fundamentals have to be strong and excellence. Thus, for India to prosper and to be knowledge superpower, it must have top class processes for pursuing scientific advances and using it successfully and also have in place mechanisms to generate, harness and exploit the creative power of modern science.

The S&T Section of the Approach Paper for XI Plan rightly calls for substantial stepping up of support to the basic research, enlarging pool of scientific manpower and strengthening S&T infrastructure, implementing selected national flagship programmes which have a direct bearing on the technological competitiveness, and establish globally competitive research facility and centers of excellence.

Thus, as a part of the overall strategy, the leap frogging approach rather than incremental steps forward, would have to be adopted to achieve the outcome and expectation from the Approach Paper. Substantial public investments would have to be made by the Government in basic research, industrial research to fuel the required industrial growth.

CSIR, based on the indications emerging out of the sector specific SWOT analysis and ZBB and considering approach to S&T as the backdrop, would be implementing Six Plan schemes during the XI Plan. While, the first five following schemes would be the continuing schemes with new programmes/projects/tasks & activities, the sixth scheme would be the new scheme:

i. National Laboratories

ii. National S&T Human Resource Development

iii. Intellectual Property & Technology Management,

iv. R&D Management Support

v. New Millennium Indian Technology Leadership Initiative and

vi. Setting up of a Translational Research Institute

I. NATIONAL LABORATORIES

In the following sections for each of the sectors, a broad national perspective, CSIR's role to provide S&T based solutions, the projects thereof such as supra-institutional, network, inter-agency and the facility creation and the budgetary requirements has been provided.

3.2(a) SECTORAL PLAN

3.2.1 AEROSPACE SCIENCE & ENGINEERING

Safe, secure and efficient air transportation is central to a nation's growth and economic development. Over the years, particularly during the last two decades, this sector has registered tremendous progress – Indian Space Research Organization (ISRO) satellite and launch vehicle programme is flourishing; Defence Research Development Organization (DRDO) integrated missile programme is achieving momentous success; India's fighter aircraft project (Light Combat Aircraft) is progressing impressively and the successful inaugural flight of 9-14 seater Light Transport Aircraft- *SARAS* in August 2004*,* a project by CSIR being implemented by NAL, signals a major step forward in the country's initiative to design and develop indigenous civil transport aircraft. Earlier, NAL had developed *HANSA,* the two-seater all-composite trainer aircraft. These developments have heralded the beginning of Indian civilian aircraft industry. The HANSA aircraft programme has been an unqualified success with half a dozen of these already flying, including three with the Hyderabad, Indore and Trivandrum flying clubs. HANSA aircrafts flying in the Indian skies have together notched up more than 2000 flying hours safely.

The India's aerospace industry has indeed come of age. Remarkable technological advancements, human resource development and an increasing public-private partnership in aeronautics spanning defence and civilian sectors are hall mark of the sector. The Indian public and private aerospace firms in association with R&D organizations have been able to harness their technologies and human resources to compete with their counterparts worldwide through co-production and joint ventures. CSIR as in the past would take a lead role in spearheading the civilian aircraft development programme in the Eleventh Plan.

Air transportation is a vital component of development and for a large country like India, a regional aircraft with an intermediate capacity (typically 70 passengers) and the range of about 2000 km is best suited to meet the requirements of establishing connectivity between regional centres and main cities.

Such an aircraft development programme to realise a certified aircraft would be a multi disciplinary and multi institutional programme to optimize the input resources. NAL's experience with the SARAS programme and technologies currently available in the country give sufficient confidence for such a programme to be taken up. However, many of these technologies will have to be upgraded and new ones will have to be developed along with state-of-the-art methodologies for success of the programme.

The aero-test facilities of NAL are comparable to the best available elsewhere globally. These facilities and NAL's testing competence have contributed vital inputs to all national aerospace programmes of the country so far. There is need to provide these high quality inputs for the current and future programmes. For the Eleventh plan, upgradation and modernization of NAL's existing facilities (both hardware and instrumentation) and build new facilities are proposed.

The strong / unique competence base already available with NAL will be consolidated and "Advanced Centres" to act as referral centres for all future aerospace programmes will be created.

SUPRA-INSTITUTIONAL PROGRAMME

3.2.1.1 Technology development and R&D initiatives in aerospace (NAL)

NAL has a very important role to play in the R&D activities leading to the technologies vital for the strategic aerospace sector in the country. NAL has built up specialized strengths and a competence base in the aerospace sector and has carved out a niche for itself. It has played a key role in the success of major national aerospace programmes (for ex: TEJAS, Intermediate Jet Trainer and Advanced Light Helicopter (both of Hindustan Aeronautics Limited), Integrated Guided Missile Development Programme (of DRDO), Satellite & Launch vehicles (of ISRO), Life Extension programme(of Indian Air Force) etc. and the technologies developed for these programmes. It has thus contributed substantially to all the national aerospace programmes of the country, thereby building within the NAL technological excellence in specific core disciplines as well as inter-disciplinary areas and systems engineering / managerial strength for indigenous aerospace projects. This has enabled an enhancement of the strategic independence of the country in a cost effective manner.

NAL functions as a broad-based engineering institution with components of research, development, technology and mission mode activities. Its level and range of activities extends from undertaking applied research and feasibility analysis, in some cases establishment of full technology in a few others, developing certain flight worthy hardware and software as required to design, development and certification of full aircraft with all its systems engineering complexity. It has proven over the years its capabilities in technology incubation at laboratory research level pilot plant/prototype level development.

Research focus

The proposed programme is to strengthen its R&D core competence aimed both at supporting the technology development and enhancing the long term knowledge base. It is therefore, proposed to take up new technology initiatives in the Eleventh FYP in the areas of Supersonic Combustion; Small gas turbine engines; MAV development and related technologies ;Special composites fabrication technologies; Structural Health Monitoring ;Damage tolerance technologies; Advanced Total Technical Life Extension Studies (TTLE) with a broader scope; Smart Materials and Technologies; Ceramic composite fabrication; Nano composites and coatings; Advanced electronics systems / avionics; Dynamic engine control; Advanced flow simulation and control, numerical and experimental techniques; Advanced Control Laws for high performance aircrafts; Air Traffic Management; Crash Worthiness Studies; Vibration and Aero-elastic control studies using smart concepts; and Aero-thermo- elastic modeling and analysis.

The proposed programme includes a substantial R&D component aimed both at supporting the technology development and enhancing the long term competence base. This is essential as the very nature of the aerospace sector implies long lead times before applications fructify.

The new R&D projects will be initiated to strengthen the technology programmes as well as to form a basis for future competence building. These will be taken up in association with academic institutions, so as to harness the available knowledge base through networking with academia. The areas in which these research projects will be taken up include: Advanced Avionics, Hypersonic Flows, Smart/Nano materials, Flow Physics, Energy systems, Dynamic Controls and Flight Research.

Envisaged outcomes/outputs

NAL will adapt its high-end technology and products to derive large volume applications for larger societal benefit (ex. energy, materials, processes etc) at affordable cost. Such an approach will result in increased contribution to the social sector (including transport, energy, connectivity, rescue and rehabilitation), a sizeable exportable R&D portfolio and an increased strategic independence for the country and also contribute to creating jobs in the civil aviation sector. With these, a higher global positioning of India as a leading aerospace power is also to be expected.

Expected Outcomes from the above proposed activities are:

- New Areas of Research which include Icing studies, In-flight measurement techniques, Glass Cockpit and instrumentation, Multi Disciplinary Optimisation, High lift devices/ techniques, Innovative composite manufacturing techniques and Health / condition monitoring
- Development of New techniques in flow computation for faster convergences, New concepts in flow control, flow stability / transition, High lift aerodynamic devices, New systems for propulsion of small vehicles, Intake Aerodynamics / Engine-airframe integration, Computation of stores separation effects / separated flows, Flow management / Drag reduction devices Simulation of Low Reynolds number turbine flows in cascade tunnel and Morphing aerofoils / application of smart material
- Studies on Dynamic and aeroelastic analysis, Flutter (full aircraft and wind turbine blades), MEMS and smart structures, Damage tolerant ,High velocity Impact / crash studies / and energy absorption, Bonded joints, Advanced fatigue and fracture and High temperature effects
- Development of Fibres, resins and prepregs, Smart materials, Nano Technologies coatings and composites, Materials and coatings for Stealth technologies, Corrosion Technologies and High temperature material
- Development of AMLCDs and practical cockpit instrumentation systems, Expert systems, Advance digital signal processing & active noise control, Stealth technologies (Studies) and Open architecture systems in the area of Avionics & Systems.

INTER AGENCY NETWORK PROGRAMME

3.2.1.2 Designing and developing a regional aircraft specially suited for developing economies (*NAL,* HAL, Ministry of Civil Aviation)

Connectivity is vital for economic development. The remote or interior regions of the country can be developed only when rapid means of communication for men and material are established.

Air transportation is a vital component of the communication network which helps to transport people on business, govt. officials, leisure travelers, transport of perishable and other goods. The networking helps to establish production centers in the interiors where there is advantage of low cost labor / raw materials / low infrastructure cost. The air transportation helps growth of interior regions which in turn helps industry / business sector to produce products at lower costs enabling competitiveness in the global market. The aircraft chosen for operation along with the airport infrastructure provided must be able to provide low cost solutions for transportation of men and materials. It would mean that there is a need for an aircraft whose acquisition and operating costs are low and also it should be capable of being operated from airports with minimal infrastructure and instrumentation facility. It may be pertinent to point out that the infrastructure cost for providing air connectivity between city pairs is lower than that for either road or rail connectivity.

The existing turboprops (ATR-42, ATR-72, etc) and turbojet aircraft (ERJ 145ER/ER170, Bombardier CRJ 200, etc) are still quite costly to acquire and also to operate due to expensive increasing cost of fuel, heavy maintenance cost and their dependence on airport ground instrumentation. There is a need for new generation of turboprop and turbojet aircraft that are cheaper to acquire and costs less to operate and are independent of costly airport infrastructure / instrumentation. Safe, nearly all weather access to any location in the country with an existing landing facility is a critical need for all round growth

This proposal is for the development of a regional aircraft with certain unique design targets viz., lower acquisition cost, higher fuel efficiency, lower maintenance cost, short take-off and landing capability and autonomous operations compared to existing aircraft of similar class.

In this multi institutional programme, other R&D agencies, industry and academic institutions will participate while NAL will be the nodal laboratory.

Research focus

Design and development of a regional transport aircraft with a seating capacity of 70 ($\pm$20). The proposed characteristics of the aircraft are:

- To keep the wing, empennage, cockpit, and systems similar to SARAS with only variation in fuselage length.
- The wing design could be common for both turboprop and turbofan variants with only changes in nacelle. A 50 pax version could be a turbo-prop and the 90 seater a turbofan while the 70 pax version will be offered as a turboprop or a turbofan.
- Lower Landing Minimum (LLM) on minimally equipped landing facilities.
- High volume operation (HVO) in non-radar airspace and non-towered airports.

➲ Increased single pilot performance – crew safety & mission reliability.
➲ Enroute procedures and systems (ERS) for integrated fleet operations

It is proposed to develop 4 prototypes,1 static test air frame, and 1 fatigue test airframe. It is also proposed that the private – public partnership model be adopted for development and production.

Phasing of the Programme

The development programme will span 7 years from go ahead to aircraft certification. The first batch of production aircraft will be available at the same time when the aircraft gets its certification. One of the key elements for the success of this programme is the development of crucial technologies. Furthermore the cost of the aircraft will be driven by cost of bought-out-items including the power plant, avionics and other systems. While development of a new engine is not envisaged, development of certain other LRU's will be initiated. The conceptual and feasibility studies will be completed first so that all parameters of the aircraft are defined with utmost clarity. The total programme is divided into two phases; the first phase concluding with a digital prototype while the second phase includes engineering development comprising of building of the prototypes, test specimens, ground and flight tests and documentation leading to certification.

Phase 1

The conceptual and feasibility studies, technology development and project definition and development of critical LRUs, detailed design and development of a digital prototype. Also during this period the necessary capital investment including IT infrastructure would be put in place. Assessment of the market potential both domestically and worldwide would be made. It is estimated that these activities would take about 5 years. During this phase, an industrial partner should be identified and agreements concluded.

Phase 2

This phase will include the full scale engineering development including ground and flight tests and certification. The phases 1 and 2 may overlap so that the over all time schedule of 7 years for certification is not extended.

Envisaged outcomes/outputs

The final outcomes of the project will be development of 4 prototypes of the aircraft, 1 static test air frame,1 fatigue test airframe and other facilities.

The proposed project will also lead to the development of spin off technologies and the advantages accrued would be as follows:

1. Airframe

New generation wing with laminar and supercritical characteristics with optimized winglets, Highly efficient high lift system and Composites components used extensively for the whole of the airframe (target: 45% of structural weight, 90% of surface area) will reduce weight, fatigue problems, corrosion problems and maintenance cost.

2. Flight controls

Fly-by-wire system which enables reliable operation at reduced stability (c.g) margins. This will results in reduced empennage size leading to reduced weight. Trim drag will also be lower for an aircraft with lower stability margin. The handling and ride qualities will be improved significantly. Simplified software based flight controls will be incorporated [reduced ownership & maintenance cost].

3. Propulsion

Fuel-efficient next generation turboprops and turbofans with at least 15% lower fuel burn and reduced number of life limited parts, "on condition" maintenance and reduced periodic overhaul.

4. General systems

- Electrical system with wild (variable) frequency in place of constant frequency generation (reduction of cost of acquisition and maintenance)
- Maximum use of electrical actuators in place of hydraulic actuators
- Hydraulic system with 5000/4000 psi system in place of 3000 psi system reducing sizes and weights.
- MEMs based sensors to reduce costs and also sizes.

5. Avionics

- Avionics based on COTS components thereby reducing cost of ownership and able to operate with variable frequency power supply.
- Glass cockpit with extensive diagnostics, eliminating need for overhaul at specified intervals and maximizing "on condition" maintenance.

6. Other avionics technologies

- GPS – WAAS – LAAS – GAGAN for high accuracy navigation information.
- Automatic Dependent Surveillance – Broadcast (ADS-B) and moving map display for better situation awareness leading to highway in the sky (HITS) concept.
- Advanced Display Systems – synthetic vision systems – combined vision (IR + visual) – moving map display.
- Low cost HVD/NOMAD HMD for better head up situation display, especially during takeoff/landing.
- Flight direction guidance.
- Conflict detection and alerting algorithms based on ADS-B data.
- Decision making based on expert systems (similar to pilot associate).
- Weather Radar data from ground based radars through DATA LINK.

FACILITY CREATION & CENTRES OF EXCELLENCE

3.2.1.3 Up-gradation and creation of facilities (NAL)

The specialized test facilities of NAL have contributed significantly to all the national aerospace programmes both in civilian and the strategic sectors run by different Institutions like ISRO, DRDO and Indian Air Force. For instance, Full scale fatigue testing facility has made valuable contributions to the technical life extension of IAF fleet of aircraft and helicopters and Composite fabrication and characterization facilities of NAL have given major inputs to the LCA programme (both prototype and LSP), NAL's civil aircraft programmes, radar programmes of NAL and the wind energy programme. It is proposed to take-up upgradation and modernization of existing facilities on a selective basis. It is also proposed to create new facilities in the emerging areas of technology development.

Aim of the facility

The main objective is to upgrade and modernize the existing facilities and to create new facilities.

A. Up- gradation of the following facilities

- National Aerodynamic Testing Facilities (NTAF).
- Acoustic Test Facility.
- Full scale fatigue testing facility
- The Engineer-in-Loop.
- Composite fabrication and characterization facilities
- Turbo-machinery component testing facilities
- Failure analysis lab
- Failure analysis lab
- High Temperature facilities

B. New facilities proposed

- Larger full scale fatigue testing facility.
- A new high capacity Acoustic Test Facility.
- Aero engine test beds
- Special wind tunnels

Envisaged outcomes/outputs

- NTAF augmentation will be completed after modernization of its instrumentation, controls and data acquisition systems and full benefits of current technologies will be realized and be better prepared to meet the country's requirements.
- Presently the full scale fatigue testing facility is capable of testing full scale military aircrafts upto and including all fighter aircrafts of MiG 29 class. The upgraded larger facility will accommodate larger aircrafts like SU30 and future acquisitions of IAF as also small civilian aircrafts.
- The Upgraded failure analysis laboratory and High Temperature facilities with particular relevance to reusable vehicles, multi discipline radome characterization facilities, specialised facilities for health monitoring of aircraft.
- The new high capacity Acoustic Test Facility for testing the components of future launch systems being planned by ISRO including interplanetary launches like Chandrayana programme.
- The new Aero engine test beds for modular testing of newly designed special systems.
- Special wind tunnels for niche applications (flutter studies on variable Reynolds number, high temperature simulation etc.), and
- Failure analysis lab to contribute substantially to all the investigations of aircraft incidents and accidents.

3.2.1.4 Advanced centre for flight mechanics & controls and centre for Micro Air Vehicles (MAV) design and development (NAL)

Control law development for flight vehicles with special reference to unstable aircraft has been proven by NAL. It has developed and proved the control laws for TEJAS aircraft (LCA). All the four TEJAS aircraft are currently flying with these control laws and the laws are being upgraded continuously by using the flight test results. Control laws for trainer and naval versions of LCA are expected to be ready. LCA programme and ADA have benefited extensively by this technology. The R&D initiated in the area of Air Traffic Management has resulted in NAL's competence being developed to a stage of practical applications. This will be an essential technology for operating future airports particularly in view of the heavy increase in air traffic in all Indian airports. Demonstration of the technology has yielded good information in the planning of Bangalore International Airport. The proposed centre is to take care of all the above mentioned activities.

Micro Air Vehicles (MAV) is an area of strategic importance to the country and NAL's competence is now sufficiently mature to enable demonstration of prototypes. This will be of great strategic importance and the multi discipline R&D strengths of NAL would make it an ideal choice for creating a Centre of Micro Air Vehicle design, development and demonstration. NAL in association with DRDO (ADRDE, Agra) has demonstrated capability to design and build Radio Controlled (RC) Blimps which will meet with long term strategic needs of the country

Aim of the centres

It is proposed to set up two specialized centres at NAL which will serve as referral agencies for all futuristic programmes. The **Advanced Centre for Flight Mechanics & Controls** will deal with Control law development for civilian aircrafts, creation of flight control databases and Air Traffic Management activities. The MAV Design Centre will be started with NAL as a nodal agency and with a few sub-centres (Indian Institute of Science, Indian Institutes of Technology, Madras Institute of Technology, National Institutes of Technology, M S Ramaiah Institute of Advanced Studies etc). Both will eventually be converted to Centres of Excellence.

Envisaged outcomes/outputs

- Consolidation of available flight control resource base and creation of a National Flight Control Technology Centre.
- Control law development for civilian aircraft to provide critical inputs to the SARAS programme.
- Air Traffic Management technology to all Indian airports will be made available. This is expected not only to ease traffic management and but also result in fuel savings.
- Multi sensor data fusion technology developed by NAL has resulted in useful inputs to the missile and aircraft programmes of the country. This will be extended to all future missile and space vehicles.
- Development of parameter estimation technology for flexible aircraft like flapping wing MAVs to meet strategic needs.
- MAV as a demonstrator vehicle to provide a flight platform for testing and proving various related R&D concepts generated by NAL.

- ➲ Use of smart materials for control applications for ex. flapping wing MAVs
- ➲ Blimps designed and flight tested in order to meet the country's strategic requirements.

Total Plan budgetary requirement projected for the Sector is Rs. 1294 crore

3.2.2 AGRO, FOOD PROCESSING & NUTRITION TECHNOLOGY

India is the world's second largest producer of food, next to China. The food and agriculture sector contributes about 26% of India's GDP. This sector is one of the largest in terms of production, processing, consumption, export and even the growth prospects of any consumer commodity. Primary food grain processing is a major industry in our country with about 80,000 rice hullers, 1 lakh chakkis, 10,000 dhal mills, more than 2 lakh ghanis and expellers and numerous traditional food industries. In the organized sector, there are around 5,000 fruits and vegetable units, around 150 sweetened beverages units, 90 milk processing units, 850 flour mills and several other food processing units. A number of these units are in the small industry and medium scale industry sectors as well. It is indeed encouraging to note that processed food exports are over Rs.13, 500 crores, that is, about 10 per cent of the total exports from our country.

CSIR considers this sector to be of prime importance to nation's economy in terms of output, employment potential and out reach to a large section of society both rural and urban. CSIR has been playing a significant role in strengthening the country's overall capability in this sector by developing technologies pertaining to various facets of food processing including machinery/equipment for food processing Industries.

Based upon competence and capacity building during last few years R&D programmes in network mode have been proposed on design and development of equipment with automation and semi-automation for the production of ethnic/traditional foods in small scale industry; innovations and emerging technologies in food processing; nutraceutical and bioactive molecules from food and non-food sources; development of transgenic crop plants resistance to insect pest, designing and development of novel proteins and indigenous promoters, screening of newer/less known oil seeds in India for commercial exploitation as edible and industrial purposes; isolation/synthesis and evaluation of nutraceuticals of vegetable oil origin and development of supecritical fluid technology for extraction, and separation of bio-active phytochemials and drug delivery.

The category of Supra institutional programmes comprise niche food processing technologies for affordable, safe, hygienic, nutritious food to the targeted population; high value products from agro forestry resources from the Himalayan region & improving productivity and quality and products development; development of evidence based herbal products for preventive health and disease management; biodiversity assessment, prospection and conservation of plant resources. Inter-agency programmes have been proposed on minimizing the food wastages through cost effective backward and forward linkages and by utilization of the by-products; technology intervention for quality product from cereals and legumes for convenience/traditional foods; bamboo:characterization, sustainable cultivation for product development of economically important bamboos. National facilities proposed comprise regional facility for nutraceuticals/cosmetically/value added products; model food processing incubation centers by CFTRI, Mysore and RRL-Jorhat; CSIR center for human resource development in food science and technology; facility for performance simulation, testing and designing of foods storage and packaging and nodal codex food laboratory and referral center for organic nutraceuticals & GM foods; center for plant biotechnology.

SUPRA INSTITUTIONAL PROGRAMMES

3.2.2.1 Niche food processing technologies for outreach of cost effective, safe, hygienic, nutritious food to the targeted population (CFTRI)

The country's economic status is directly dependent on the health of its population that contributes largely to its productivity. If malnutrition is not addressed, the country would suffer predominantly due to physical and mental disorders, learning impairment among children and loss in productivity among others. Annual loss to the GDP due to hidden hunger is estimated at Rs. 27,720 crores (approximately Rs. 256/person/year). The emphasis of the project is on the development of Supplementary and Complementary Foods: Nutrient fortification of staple and non-staple foods; Foods with a life-cycle approach; Cognitive foods: utilizing indigenous resources; and High Intensity Nutrition for targeted population.

Research focus

- Food fortification to combat micro and macro nutrient deficiencies.
- Understand the basis and needs of specific nutrients at different ages and identify vehicles for their delivery.
- Design foods that cater to the varying needs of different populations based on age .
- Identify dietary factors and their sources that could be important in enhancing cognitive skills in children below age five and also prevent cognitive impairment in the aging society.
- Proper nutritional support to targeted population needing high intensity nutrition including immuno-modulatory components.
- To develop supplementary and complementary foods that augment nutrition availability.
- High density multiple nutritious products and specialty foods for outreach programmes.

Envisaged outcomes/outputs

- Effectively address both micro and macro nutrient needs of the population through fortification of staple and non-staple foods.
- Tools (Food Products) that would enhance the cognitive performance of children and check cognitive impairments in the aging society.
- Nutrient dense food products that meet the requirements of hypercatabolic group.

3.2.2.2 High value products from agro-forestry resources from the himalayan region and improving productivity and quality, and product development (IHBT)

The proposed studies will lead to production of quality planting materials of lilium, gerbera, carnation, marigold, cymbidium and apple; development of Package of Practices (POP) for saffron, gerbera, lisianthus and cymbidium, development of farm implements for planting, digging and sorting, development of hybrids in gerbera and lavender,domestication, evaluation and utilisation of wild plants; development of Integrated Disease Management

(IDM)/Integrated Pest Management (IPM) package for Apple, Rose, Saffron and Tulip, Orchids. An improved agro-technology package will be given with an integrated pest management based on ecofriendly approaches for quality tea production. The work will lead to the development of database on tea germplasm, marker aided selections for tea breeding, development and testing of tea transgenics under contained facility. Technology for diversified tea products and nutraceuticals production would help in value addition of the manufactured products. Identification of blister blight tolerant clones, and development of hybrid clones with desirable yield and quality will lead to substantial gains to the tea economy in the region. Partial genome sequencing will have a significant impact on tea research community as well as genomic research studies on other perennials.

Catechins and other antioxidants are in high demand these days and necessitate development of alternative source of catechins and their condensed products. Development of alternative source such as in arabidopsis/tobacco for producing catechins and production of theaflavins and thearubigins in bioreactors will be rewarding in terms of time, energy and the cost.

Research focus

Activity I

Apple

- Collection, characterization and evaluation of root stock for quality fruit production
- Development of Micropropagation and transgenic protocols.

Rose

- Characterization, genetic improvement, bioprospection and product diversification of *Rosa* spp with respect to scented, ornamental and wild roses

Saffron

Production of commercial size corms and forcing technique

Tulip

- Fundamental studies on tulip bulb multiplication

Orchids

- Generation of hybrids
- Other activities
- Generation of regional nucleus planting stocks in lilium, gerbera, carnation
- Development of agro-technology and mechanization systems for commercially important flower crops
- Genetic improvement in important flower and oil bearing crops such as gerbera and lavender through conventional and molecular approaches
- Domestication and utilization of wild plants
- Development of Integrated Disease Management (IDM)/Integrated Pest Management (IPM) package for Apple, Rose, Saffron, Tulip and Orchids

Activity -II

- Collection, Characterization and Inventorization of Germplasm
- Germplasm enrichment, description and database development

- Morphological, biochemical and molecular characterization
- Identification of contrasting phenotypes for developing linkage maps populations
- Segregating populations for desirable traits, such as resistance against blister blight
- Isolation and development of hyper variable co-dominant markers
- Utilization of molecular markers for development of genetic maps
- Partial genome sequencing
- Characterization of regional finger prints for volatile flavour components

Organic Farming Practices Specific to Tea

- Standardization of techniques for composting litter biomass of tea and allied plants
- Evaluation of composts for soil fertility management, yield and quality
- Development and evaluation of biopesticides and biofertilizers for yield and quality
- Assessing economics of organic cultivation

Innovation in conventional tea husbandry techniques

- Standardization of mechanical pruning and skiffing vis-à-vis fertilizer application in terms of yield and quality
- Ergonomics of mechanization in tea
- Feasibility of complete mechanization of farm operations
- Water response functions for young and mature tea
- Integrated disease, pest and weed management
- Production of quality tea

Process technologies

- Manufacturing process for oolong tea, scented and flavoured teas Process technologies for herbal tea wines, concentrates, ready-to-drink teas
- Heterologous system for production of theaflavins and thearubigins
- Large-scale production of PPO through bioreactors
- Decaffeinated tea through RNAi technology
- Low cost tea manufacturing units
- Dormancy Regulation by genetic Transformation
- Sensitive instrumental methods for detection of polyphenols

Product development

- Up-scaling production of theaflavins, catechins and polyphenols in bioreactors
- Caffeine and saponins
- Production of theanine through hairy root culture and biotransformation
- Encapsulated tea flavours
- Herbal, flavoured and scented teas
- Tea wines
- Aide to controlled plucking
- Rapid wither machine for orthodox tea (incremental advancement)
- Biofertlizers

Envisaged outcomes/outputs

- Development and Transfer of Technologies related to transgenic protocol for Apple Virus free plant production protocols for Apple, Cherry, Plum, Saffron and Orchids, viral diagnostic kits for major viruses and viroids, multiplexing protocol for Rose, Saffron and Tulip, Orchids, Carnation, Chrysanthemum, Lilium viruses, antifungal gene constructs for chitinase and glucanase

Papers	-	60- 80 nos.
IPR/Patents/Registration	-	15- 20 nos.
Farm implements	-	2-3 nos
Technical folders/Books	-	8-10 nos.

- The above mentioned transfer of technologies will result in employment generation of approximately 5 lakh mandays in 5 years

3.2.2.3 Development of evidence based nutraceutical herbal products for preventive health, disease management and therapeutic applications (RRL,Trv.)

India with its rich bio-diversity and traditional knowledge could become the world leader in cost effective complementary health care based on scientific evidence nutraceutical and herbal products for preventive and therapeautic values. Plants as source of pharmaceuticals is a well known as 25% of the prescription drugs available today are plant derived. There is a need for development of nutraceuticals/herbal products by integrating the traditional knowledge with modern scientific approach towards standardization and validation. The nutraceutical products primarily aim at preventive health and disease management with identified chemical and bio markers to establish their bio-potency. The research will establish the association between anti-oxidants from the selected plant (active fractions/pure compounds) and their ability to prevent, control and cure cancer, CHD and inflammation. Standardization and validation of nutraceutical and herbal products now are essential prerequisite to get access to the export market and loss of export market would thus lead to huge economic loss. A close interaction with traditional medical practitioners of the region is proposed for identification and selection of the plant materials standardization and validation for prevention of target diseases like CHD, Cancer, diabetes and inflammation.

Research focus

- Chemical characterization and finger printing of the selected plants/plant products
- Activity guided fractionation and identification and structure elucidation of chemical markers
- Evaluation of active fractions for CHD, diabetes, cancer and inflammation using *in vitro* model (chemical, biochemical and cell culture)
- Standardization of the plants /plant products in terms of quality and quantity of chemical markers
- Pharmacological, pharmacokinetic and toxicological studies of the active fractions to establish bio-potency and effective doze (out sourcing)
- Identification and structure elucidation of biomarkers and their correlation with chemical markers.

- Process development and scale up studies at pilot scale for the production of active fractions
- Development of formulations using active fractions (single and/or polyherbal)
- Development of user friendly product delivery systems (e.g spray dried beverage powder) and other appropriate carriers suitable for end use applications
- Limited clinical trials using the formulated nutraceutical products (phase 1) (out sourcing)

Envisaged outcomes/outputs

- Standardised and validated Nutraceutical Products for Preventive, therapeutic and disease management, technology transfer and commercialization
- Novel processes for extraction and fractionation of bioactive phytochemicals from 10 plant/plant products for commercial production.
- Finger prints and marker compounds of the plants and the final products.
- Nutraceutical products supported with evidence based on invitro and invivo protocols including clinical evidence for CHD, diabetes, cancer and inflammation.
- Formulation of user friendly nutraceutical delivery systems for commercialization (eg. beverage, powder, diet supplements etc
- Phytochemical standards for the plant/plant products used in traditional medicine
- IPR related to novel bio-active molecules and products.

3.2.2.4 Biodiversity assessment, prospection and conservation of plant resources of India (NBRI)

Biodiversity in plants is an invaluable resource base with manifold values to humans as new or alternate sources of food, nutrition, medicine, energy, agriculture, biotechnologies, and industry. Whereas 10-15% of the known higher plants have been screened globally for their potential for food, nutrition and biomolecules, the lower plants, such as algae, lichens, bryophytes and pteridophytes remain as an unutilised or under-exploited resource systems. Much of current R&D is focussed on bioprospection of higher plants, but efforts are minimal on untapped potentials of the lower plant groups. The new and rapidly transforming biotechnologies and bioprospection regimes underscore the need for new and alternate sources of food, food supplements, nutrition, biomolecules, etc. to overcome the problems of hunger, malnutrition, diseases, crop loss, environmental degradation and loss of biodiversity. The current loss of plant species and their genetic diversity in India have great irreversible impacts on the ecology and economy of our country.

Research focus

This supra-institutional project will focus on in biodiversity, particularly of the lower plants, by undertaking a series of trans-disciplinary research programmes aimed at biodiversity assessment, digitalized documentation, conservation, evaluation and bioprospection of the less known, unexplored and under-exploited plant wealth of India and associated traditional knowledge. The project will also have a strong focus on characterization, conservation and evaluation of potential plant resources among non-conventional food plants (e.g. legumes, amaranths, wild edibles including fruits, vegetables, etc.), ferns & fern allies, mosses & liverworts, lichens and algae.

Envisaged outcomes/outputs

- Systematic accounts of at least two bryophyte genera (*Plagiochasma* and *Asterella*).

- Identification of new anti-fungal molecules from ferns, mosses and liverworts.
- Identification of air and metal pollution indicator, tolerant and phyto-remediator ferns, mosses, liverworts and lichens.
- Discovery of new pathways and genes for drought resurrection in ferns and mosses
- Identification of high hydrogen evolving algae.
- Technology for *astaxanthin* production from algae.
- Establishing new knowledge on growth, development, reproduction in plant life
- Preservation of ethno-botanical heritage and plant biodiversity of country.
- Publications: 15-20; Patents: 3- 4

NETWORK PROGRAMMES

3.2.2.5 Design and development of equipment with automation and semi-automation for the production of ethnic/traditional foods in small scale industry (*CFTRI,* CMERI, CSIO,NAL)

The landscape of foods is changing very fast both at national and international levels. Novel foods are flooding the markets, where our time-tested traditional foods can also bloom. There is a vast scope and need for elevating the status of many of the ethnic/ traditional Indian foods. It is therefore necessary to standardize and mechanise the production system with the appropriate food machinery for small scale industry. The need for the machinery envisaged is felt badly by the industry and this could upgrade the status of Indian traditional foods in the national and international scene. This would provide scope for wider domestic marketing and export of traditional foods. The proposed activity enable to revive the Indian ethnic/ traditional food by designing and developing equipment for traditional foods.

Research focus

- Design and development of appropriate processing machinery and to mechanize the production of ethnic/traditional foods.
- To popularize ethnic/traditional foods and to promote small scale industries.
- To develop technologies for ready-to-eat and ready-to-cook low cost foods.

Envisaged outcomes/outputs

- Integrated unit for extruded foods.
- Machine for puffed/popped foods.
- A versatile compact machine for toasted/roasted low fat foods.
- Machinery for formed foods.
- Unit for shaped foods.
- Machinery for filled foods.
- Technology for low cost easy-to-cook or ready-to-eat foods.

3.2.2.6 Innovative and emerging technologies in food processing (*CFTRI*, CMERI, NCL, NAL, CSIO,IISc, ICT-Mumbai)

The speed of process/product innovation in the food industry has changed dynamically. The half time of process/product development has decreased 10 fold in the last 35 years. Due to increasing demand for safe and quality processed food and increasing energy cost, there is a need for innovations and new technologies in food processing in order to make the food industry competitive, diverse and efficient. The new technologies significantly contribute to energy conservation and would enable industry to provide safe and quality food to the population at large without much additional cost. This also addresses food security aspect by means of the food preservation technologies developed.

Research focus

- Application of Natural Gas in food processing industry to conserve energy especially in the energy intense operations such as baking, roasting, spray drying, steam generation etc.
- Employing of external fields (such as ultrasound and microwave) to conserve energy and to improve productivity in food process unit operations such as evaporation, freeze drying etc.
- Using multiphase computational fluid dynamics (CFD) in combination with thermodynamics and physics of local structure forming processes such as, agglomeration, nucleation, crystallization, phase separation, etc. for the smart design of food processes and stimulation of their scale up.
- Application of nanotechnology for the development of novel food processes and packaging solutions.
- To develop food preservation and processing methods that improves nutrition and sensory quality by employing external fields (such as pulsed electric/light fields, radio frequency/infrared irradiation etc.).

Envisaged outcomes/outputs

- Natural Gas based food processing operations such as baking, roasting, spray drying, steam generation etc.
- Energy efficient food processing unit operations such as evaporation and freeze drying etc. based on external fields such as ultrasound, microwave etc.
- Extraction/reaction/precipitation processes with significantly high productivities based on nanotechnology.
- Hybrid process technologies for preservation and processing of fruit juices, milk, meat etc. based on application of external fields such as pulsed electric field/light fields.
- Improved design and scale up stimulation of selected food processes such as agglomeration, nucleation, crystallization, phase separation, etc. based on Multiphase computational fluid dynamics (CFD).

3.2.2.7 Nutraceuticals and bioactive molecules from food and non-food sources (*CFTRI*, RRL-Jammu, IHBT, NBRI, CIMAP,NIO)

India has wide biodiversity and traditional knowledge on tropical and temperate plants for utilization in food and medicines. Herbs and spices are being studied worldwide as the sources of nutraceuticals. There is tremendous opportunity to link the traditional knowledge with the information on the biological activities of the specific phytochemicals to appropriately utilize them for use in health foods, as nutritional supplement and also as nutraceuticals. Since there is an increasing demand globally for personalized foods, personalized medicines and designer foods, the relevance of this programme for production of bioactive molecules and nutraceuticals and their utilization is of high importance.

Research focus

- Isolation, characterization of secondary metabolites such as vanillin, carotenoids, spices principles, steviosides and natural pigments including their metabolomics and genomics.
- Biosynthetic studies of carotenoids and steviosides.

- ➲ Biosynthetic studies on the secondary metabolites from curcumin, spices, herbs, fruits and vegetables and understanding their regulations.
- ➲ Downstream processing of the secondary metabolites and studies on their stability and utility as nutraceuticals/functional foods.
- ➲ Genomic studies on the selected secondary metabolite.
- ➲ Safety evaluation and regulatory aspects.
- ➲ Evaluation of potential of *Salicornia* for nutrients enhancement in vegetable salt, and integrate the process with extraction of linoleic acid from seeds.

Envisaged outcomes/outputs

- ➲ Isolation, characterization and biosynthetic studies on vanillin, carotenoids, spice principles, steviosides and natural pigments.
- ➲ Bioactive peptides from various food sources, their production and validation of bio-functionality.
- ➲ Elucidating biological activities of potential molecules of nutraceutical, importance from food sources and also from non-conventional sources and downstream processing.
- ➲ Stability of the nutraceutical components in processed foods and development of stable formulations with specific end uses such as for utility in designer foods.
- ➲ Metabolomic and genomic studies of the secondary metabolites from various sources.
- ➲ Enrichment of vegetable salt with micronutrients.

3.2.2.8 Development of transgenic crop plants for resistance to insect pests (*NBRI*,NCL,IICB)

The development of transgenic crops, engineered for resistance to insects pests has made a difference in agricultural economy globally. Globally there are major gaps in the non-availability of specific genes (or proteins) with high toxicity to sucking pests (aphids, jassids, white flies etc.), promoters for tight regulation of genes, for insect feeding and phloem specific expression etc. The comparable transgenics need to be developed with indigenous technologies for crops including pulses, vegetable crops, cotton and rice. The application of gene transfer technology for various insect resistance genes like delta endotoxin, proteinase inhibitors, lectins and amylase inhibitors into crops and horticultural plants provide an economical, sustainable and ecofriendly alternative to synthetic pesticides for integrated pest management. The proposed project aims to develop stable transgenic lines of Indian cotton varities, chickpea and groundnut improved for resistance to field insects and predominant sucking pests

Research focus

- ➲ Designing of novel Bt-cry genes or pyramiding of Bt-cry genes(cry IAc,cry IAb, cry 2Ab and cry 1EC) for effective and broad range efficacy against target insects.
- ➲ Characterization of receptors on stylet and midgut of sucking pests for designing of hybrid or chimeric proteins affective against these insects.
- ➲ Isolation, cloning and characterisation of non-host proteins inhibitors from plants such as bitter gourd, capsicum and winged bean.
- ➲ Development of stable transgenic lines of cotton,chickpea, groundnut and tomato with newer strategies for enhanced resistance to target insects including sucking pests.
- ➲ Development of hybrid or fusion Bt-*cry* genes coding novel Cry toxin for broad host range, multiple receptor binding and efficacy against target insects.

- Screening and evaluation of plant diversity for novel toxins and proteins against sucking pests, identification of genes , modification and expression in cotton and chick pea.
- Development of synthetic promoters with inducible and tissue specific expression of target proteins in transgenic plants against infestation
- Constructs of genes for high level expression of chimric larvicidal and insecticide toxins proteins in transgenic lines.
- Over expression in PI yeast system, *Pichia pastoris* and testing *in-vitro* and *in vivo* potential of recombinant PI proteins against *Helicoverpa armigera* and other lepidopteron insect pests.

Envisaged outcomes/outputs

- Technologies for genetic transformation of nationally important crops and Transgenic crop varieties of cotton, chickpea, groundnut and tomato for improved insect resistance including sap-sucking pests.
- Globally competitive Bt-cotton, Bt-chickpea, Bt-groundnut with pyramiding of different genes.
- Novel receptors and binding peptides for sucking pests.
- Chimeric indigenous insect specific genes against field insects including sucking pests.
- Artificially designed promoters with inducible high-level expression on transgenic plants.
- Technology for computational modeling and designing for chimeric proteins for expression in plants.
- Proteinase inhibitor genes from different sources.
- Recombinant proteinase inhibitors with specificity and stability.
- Transgenic plants of model and target species chickpea and cotton tolerant to insect pests.
- Knowledge about the structure of PI proteins and P1-Proteinase complex.
- Publication of research papers (8-10 Nos.) and patents (3-4.Nos.)

3.2.2.9 Isolation/synthesis and evaluation of nutraceuticals of vegetable oil origin (*IICT,* CFTRI)

Vegetable oil-based nutraceuticals are gaining interest in recent times due to several health benefits. The advantage of using nutraceuticals over pharmaceuticals is its absolutely zero side effects. This project is aimed at preparing several nutraceuticals by isolating from vegetable oils or by-products of vegetable oil processing industry by different extraction methodologies. A few nutraceuticals will also be synthesized chemo-enzymatically for commercial exploitation. Isolated/prepared nutraceuticals will be evaluated for various nutraceutical properties.

Research focus

- Upscaling of process for the preparation of nutraceuticals like trans-free vanaspati and diacylglycerols
- Exploratory studies followed by upscaling of selected products for the preparation of conjugated linoleic acid, isoflavones, saponins, carotenoids, squalene, modified phospholipids, gallic acids and ellagic acids etc.,

Envisaged outcomes/outputs

- The main outputs of the proposal are isolation/synthesis and evaluation of nutraceuticals of vegetable oil origin for commercial exploitation.

3.2.2.10 Development of supercritical fluid technology for extraction and fractional separation of bio-active phytochemicals and drug delivery (*RRL-Trv*., CFTRI, IHBT,CIMAP,CMERI)

Supercritical fluids (SCF) are now considered potential solvents of the future. Solvent properties of supercritical fluids have been recognized for over a century although, their potential for processing and separation applications has not been widely investigated with few exceptions until the last few decades. The R&D challenges therefore are to harness SCF for operations related to extraction, fractionation and isolation etc. of high value bio-active molecules and other high value applications like drug delivery system based on nano particles on continuous mode. SCF based drug nano particles and liposome technology can bring out drastic reduction of the drug dosage to the target tissue leading to enhanced bio-availability, low side effects and thus better quality of life of patients.

Research focus

- Kinetic studies using SCF and construction of phase diagrams for model compounds from selected plants, oilseeds and spices.
- Development of process for extraction and fractionation and separation of active compounds from selected plant/plant products for health care applications using supercritical fluids
- Development of process for extraction and separation of functional molecules from oilseeds and fats and oils (eg.lecithin, wax, isoflavones, lignans, antioxidants, DHA, EPA, γ-linoleinic acid, etc) using supercritical fluids.
- Development of process for bio-catalysis in the supercritical fluid medium for trans esterification of functional fatty acids.
- Development of process for Extraction, fractionation and separation of oleoresin and active principles from spices (curcumin, capsaicin, carotenoids, gingerol, piperine and others) using supercritical fluids.
- Development of process for nanoparticles of selected active compounds (curcumin, gingerol, piperine, capsaicin,drug etc) with supercritical fluids (RESS & SAS) and liposome encapsulation for drug delivery.
- Characterization and evaluation of the bio-active phytochemicals and products separated by SCFs.

Envisaged outcomes/outputs

- Techno-economically viable supercritical fluids technology as an ecofriendly alternative to organic solvents for commercial application in the area of Natural Products, bio-catalysis and drug delivery.
- Supercritical fluid technology for fractional separation of natural products for health care applications.
- Supercritical fluid technology for bio catalysis to produce functional products.
- Technology for nano particle formation of bio-active molecules and liposome encapsulation for drug delivery.
- Publications and IPR related to novel bio-molecules and products and processes.
- Process design and engineering of continuous fractional separation of phytochemicals (solid-liquid and liquid-liquid separation)

INTER-AGENCY PROGRAMMES

3.2.2.11 Minimizing the food wastages through cost effective backward and forward linkages and by utilization of the by-products (*CFTRI,* IHBT, RRL-Jorhat, CLRI,CIMAP,RRL-Jammu, IICT, IARI-Delhi, IIHR-Bangalore, NHB, NDDB, ANNAND, APEDA-Delhi, NDRI-Karnal, UAS-Bangalore)

Waste material is being generated in enormous quantities with the growing food processing industry in India namely fruits and vegetables, dairy, meat, rice and pulse milling, spice and plantation product industries. This waste material contains many valuable by-products, which need to be recovered by developing appropriate technologies resulting in value addition to the tune of about Rs. 10,000 crores. The technologies developed from the project shall help in producing value added products from agri-horticulture resources and from food processing industries by-products. The conversion of the processing waste in to value added products shall result in economic benefits to the farmers and processors. The waste utilization also reduces the environment pollution and waste disposal problems. This approach will result in significant generation of high value products and allow better prices for the farmers and processors. Integrated processing technologies for fruits, vegetables, cereals, meat, fish, poultry, spices condiments and milk through good harvesting, storage, transportation and distribution practices are the key issues for prevention of food wastages.

Research focus

- Prevention of post harvest losses in fruits and vegetables, and value addition, linked with byproduct utilization through practical methods of harvesting, infestation control, packaging, storage and transportation.
- Application of non-thermal techniques for processing of milk into novel Indian milk products.
- Technologies for mechanized manufacture of Indian milk products.
- Technologies to improve the quality of meat products for enhancing the export potential.
- Technologies for the extraction of high value products like pectin, carotenoids, flavonoids, fiber and fat from the fruit processing wastes.
- Processes for value added products from spent spices of oleoresin industries.
- Processes for value added products from tea and coffee waste like theaflavins/theanine, polyphenols, and polysaccharides.
- Cost effective methods for Rice bran oil rich in Oryzanol through physical refining methods
- Value added products from rice brokens, pulse edible cotyledons and maize glutens
- Protein rich food ingredients from defatted oil seed flours.
- Bioactives from whey protein concentrates.
- Process for value added products from meat and marine industry wastes

Envisaged outcomes/outputs

- Enhancing the storage life of fruits and vegetables by minimizing the post harvest losses and value addition, through backward and forward linkages including utilization of byproducts from fruits and vegetable processing.
- Processes for the novel milk products.
- Integrated mechanized systems for the manufacture of Indian dairy products.

- A Process for the extraction and concentration of Pectin, Carotenoids, enzymes, dietary fiber from processing waste of fruit and vegetable industries.
- Value added products from rice brokens,pulse cotyledons, wheat germ and maize glutens.
- Process for rice bran oil highly enriched in Oryzanol by physical refining.
- Process for wheat germ oil enriched in tocopherols.
- Oil seed meal based high protein functional ingredients free from anti-nutritional factors.
- High value products like modified starch, colours, pectins, flavonoids from the byproducts of chilli, turmeric and ginger oleoresin industry and from coffee, tea and cocoa.
- Protein concentrate and bioactives from whey.
- Process for value added products like protein hydrolysates, collagen, chitin/chitosan, carotenoids from meat industry wastes.

3.2.2.12 Technology intervention for quality products from cereals and legumes for convenience / traditional foods(*CFTRI,* MERADO-Ludhiana, RRL-Jorhat, RRL-Tvm. ICAR)

Indian traditional foods are mainly based on major cereals and legumes. The technology intervention over the years has resulted in several types of instant mixes which on preparation yield products similar to commonly consumed foods. However, high potential of minor cereals and legumes for use as quality ingredients in the preparation of convenience and traditional foods has not been exploited. There is a need to upgrade the sensory quality through application of appropriate food processing technologies to make these food grains acceptable to the non-traditional consumers. The technological interventions in processing minor cereals and millets will increase the availability of food grains in the form that is acceptable to the consumers. Besides, the intervention will help in streamlining traditional food processing sector resulting in improved processing methods that will yield quality end products. Small and marginal farmers who are the cultivators of minor cereals and legumes may get economic benefits as the products from these commodities will find wider markets because of increased health awareness among the consumers. The project aims at enlarging the bowl of food grains / legumes that could be used in the preparation of common man's food. It will deliver quality products of wheat milling, superior quality rice, and region specific convenience / traditional foods from maize, sorghum and millets by applying appropriate technologies, modification of machinery and quality improvement techniques.

Research focus

- Application of appropriate milling, High Temperature Short Time Treatment, malting and hydrothermal methodologies for improving the yield and quality of ready-to-use products from maize, sorghum, millets and grain legumes.
- To adopt technological intervention for paddy processing and wheat milling to obtain superior quality rice and milled wheat products.
- Development of value added ready-to-eat and mass consumption products such as shelf stable flours from processed minor cereals and millets.
- To develop technologies for region specific convenience / traditional foods based on minor cereals and legumes, and also to promote export trade of Indian traditional foods.

- To integrate sensory quality evaluation in the quality testing protocol at all stages of product development including formulation, process optimization, quality specifications and consumer acceptance.

Envisaged outcomes/outputs

- Technologies for manufacturing shelf-stable edible grade semolina and flours as well as ready-to-eat products from maize, sorghum, millets and grain legumes for specific end uses.
- Superior quality rice and milled products from wheat having better consumer acceptance.
- Traditional foods and products similar to traditional foods containing value added ingredients based on minor cereals and grain legumes.
- Technologies for production of convenience foods specific to different regions and strata of population.
- Protocol for overall quality assessment of convenience and traditional foods both for domestic and export market.

NATIONAL FACILITIES

3.2.2.13 Regional facility for nutraceutical/ cosmetical/ value added products (IHBT)

The establishment of regional facility for nutraceutical/ cosmetical/ value added products will be useful for safety evaluation of herbals, food and cosmetics to enable the commercialization and marketability of R&D products. The facility will also cater to the monitoring and assessment of Indian market and industrial products.

Aim of the facility

- The facility would evaluate/identify:
- Microbial load, objectionable microorganisms, and their toxins
- Pesticide residues
- Metal analysis (including heavy metals)
- Toxicity evaluation of herbals, food and cosmetics
- Quality control and quality assurance of herbal products

Envisaged outcomes/outputs

- Creation of regional facility for safety evaluation of herbals, food and cosmetics will enable the commercialization / marketability of R&D products. The facility will also cater to the monitoring and assessment of market and industrial products.

3.2.2.14 Model food processing incubation centres (CFTRI, RRL-Jorhat)

Encouraging growth of knowledge driven business is crucial for future economic development of the country. Emerging technological and knowledge based food processing ventures seek nurturing of ideas from professionals for which one need to go beyond the traditional venture capital activity. Such entrepreneurial ideas have to be fostered and developed in a supportive environment before these become attractive for venture capital. Hence, the need for incubation centres. Incubation centres at academic and research institutions can provide the right kind of mentoring and expertise required to develop the entrepreneurial ideas in knowledgebase sectors.

Aim of the facility

The objective of the incubation centres would be to nurture start-ups food based cottage and SMEs, and encourage early stage innovation through appropriate hand holding mechanisms. The centre would encourage commercialization of upgraded traditional knowledgebase and innovation led developments, and shall provide a breeding ground for start up of technopreneur in cottage, small and medium scale enterprises.

The proposed incubation centres shall have the following aims and objectives:

- To incubate technology based innovations and help commercialize them through an enterprise.
- Scaling up intellectual property into commercialisable knowledgebase.
- Provide infrastructure and support services to entrepreneurs.
- Train the trainers including training the trainers for milling, value addition, by-products utilisation and marketing.
- Provide support for commercialization of R&D outputs.
- Create technological awareness and consciousness in existing Small and Medium Enterprises (SMEs)
- Conduct training programmes for Human Resource Development and Entrepreneurship Development in the area of Food Processing.

Envisaged output/ outcomes

- Nurture, foster and mentor the innovators to successfully commercialise their innovative ideas through an enterprise by providing the required supporting infrastructure and network resources over a time-bound period (usually 24 months).
- Catalyse the commercialization of the innovations by developing the networks of people and institutions to assist incubation projects with technology support, testing facilities, materials, prototyping facilities, lawyers, patent filing experts, venture capitalists etc.,
- Providing the linkage to the innovator with an appropriate technology network for providing support on various complementary assets that would be required in the commercialization process. This would range from market analysis, development of a business plan to prototyping, manufacturing planning, etc.

3.2.2.15 CSIR centre for human resource development in food science and technology (CFTRI)

A progressive nation is reflected in its healthy human population. This could be achieved through providing quality and trained human resource for food processing industries which provide foods which are nutritious, safe and healthy. There is a requirement towards building up Centre of Human Resource Development in CFTRI, Mysore with an objective to develop Quality Human Resource for taking forward food processing sector with emphasis on nutrition, safety and health for human population, impart knowledge and expertise in agro and food processing through intensive training programmes of diverse pattern, reach-out to society through training programmes targeting Self Help groups, NGOs, Tribal groups, Working Women's forum, Community Development Organizations and like. A modernized national facility for performance simulation, testing of packaging materials and design food packages will be created at par with International Standards. The facilities created will be helpful to packaging material manufacturers to provide tailor made packages for various food industries.

Aim of the centre

- ➲ Conduct the programmes of M.Sc. (FT) with a professional approach keeping in line with the scenario elsewhere, globally.
- ➲ Conduct the ISMT programme in an environment which gives linkage to the industrial set-up
- ➲ Short term training programmes to be organized in a manner more appropriate to the background of participant.
- ➲ Provide an environment of their expectations to the international participants coming under international study/research programmes

Envisaged outcomes/outputs

- ➲ Human resource with high academic excellence and professional approach
- ➲ Trained manpower to boost the food processing sector through intellectual knowledge and exposure to scientific and technological developments
- ➲ Develop need based training modules in the areas of food science and technology, so as to sharpen the knowledge and skills of personnel involved in food processing

3.2.2.16 Nodal codex food laboratory and referral center for organic, GM and nutraceutical foods (CFTRI)

There is a greater demand for testing of foods for quality and safety of foods for improving the quality of processed foods for internal consumption and also for export standard requirements. With limited facilities and greater demand for testing of food articles by the public and private agencies the upgradation of Nodal Codex Food Laboratory's overall testing requirements has to improved.

In addition there is a need to establish National referral laboratory to test the organic foods for quality and to ensure safety and promote overall production and marketing of organic foods for domestic consumption as well as for export to meet the stringent National and International Standard requirement.

Aim of the facility

- ➲ To improve infrastructure facility including building and instrumental facility to meet the latest international regulatory and standard requirement for contaminants.
- ➲ To meet the testing requirements of organic foods materials(specially processed).
- ➲ To meet the testing requirements of organic foods (infrastructure and equipment).
- ➲ To serve as a capacity building centre for the country for testing of foods in general, GM and organic food.
- ➲ To ensure capacity building in HACCP, GMP, GHP standards in food processing.
- ➲ To train the food industries and food testing laboratory personnel both within the country and abroad in food testing.
- ➲ To create data base on International food regulations and codes standards.
- ➲ To prepare National view points for the agenda items of various codes meetings (providing scientific justification)

Envisaged outcomes/outputs

- ➲ Fulfill international regulatory requirements
- ➲ Increase intake of samples to be analysed especially for the export market
- ➲ Improved food safety net in the context of GM and organic foods.

- Meet the nation's requirements in the area of testing GM and organic foods in addition to nutraceuticals helping both food safety and export volume.

3.2.2.17 Centre for plant biotechnology (NBRI)

It will be a unique centre for transgenic plant technologies, genomics, metabolomics, protemics, affimatrix microarrays, plant products, standardization, marker bioactive molecules, commercialization of NBRI-IPR, joining IPR with industries and referal center for quality assessment of different items. It will also become a nodal center for state/central government organization of agriculture, seeds, biotech, organic farming and herbal products sectors.

Aim of the facility

- Genetic transformation facility for economically important crop plants.
- Validation of promising candidate genes of economic importance isolated in the country for plant improvement.
- Development of specialized promoters and vectors for genetic engineering.
- Controlled environment facilities for faster advancement of crop generation.
- Controlled climate chambers for precise physiological studies to validate gene and promoter function.
- DNA fingerprinting facility for varietal registration, hybrid seed purity and bar coding for authentic plant identification and biodiversity inventorisation.
- Generation advancement to validate stability of transgene and trait _expression.
- Genomic facilities for detection of trait specific EST's and SNP's.
- Metabolomics facility to develop trait specific chemical fingerprints and identify specific biomarkers.
- Intellectual Property Management and advice in the niche area.

Envisaged outcomes/outputs

- Technologies for genetic transformation of nationally important crops.
- Transgenic crop varieties improved for insect resistance, delayed ripening (shelf life) and value addition.
- Globally competitive Bt-cotton, Bt-chickpea, Bt-groundnut with gene pyramiding.
- Novel receptors and binding peptides for sucking pests.
- Development of herbal combinations and their validation and biosafety assessments.
- Chimeric insect specific genes indigenous with intellectual property.
- Designing plants as bioreactor for expression of therapeutic proteins.
- Artificially designed promoters with inducible high-level expression.
- 'Centre for Plant Biotechnology Enterprise' to develop partnership with agro industry.
- 'Centre for Agribiotech Intellectual Property Analysis' to provide leadership to agro industry, GMO detection, biosafety assessment and chemical-biochemical validation of plant products.
- Single window guidance to industry for project development in agribiotechnology, partnership search and regulatory clearance for transgenic release.

Total Plan budgetary requirement projected for the Sector is Rs. 430 crore

3.2.3 BIOLOGY & BIOTECHNOLOGY

There is a huge market potential for biotechnology products which include transgenic value added crops, new generation vaccines, therapeutically important bio-molecules, fermentation derived bio-chemicals and a host of user friendly technologies. Indian biotechnology capability is gaining global visibility and is being tracked for emerging investment opportunities. Biotechnology industry in India has been growing at an average annual rate of 40% during the last five years and its turn over during 2004-05 has exceeded US $ 1 billion.

CSIR has emerged as major R&D agency with many of its laboratories contributing significant R&D outputs and technologies in the areas of genomics, proteomics, molecular biology, immunology, bio markers, bio molecules etc.

R&D programmes in network mode have been proposed on Gene-Environment Interaction; Cell Tissue Engineering of Plants; Plasma Proteomics: Health Environment and Disease; Regulatory RNA in Development, Health and Disease; High altitude biology with focus on Indian cold deserts; Exploitation of India's rich microbial diversity; Engineering peptides and proteins for new generation therapies; Pathway engineering and system biology approach towards homologous and heterologous expression of high-value phytoceuticals (artemisinin, taxanes, picrosides, morphine, withanolides, podophyllotoxin); Biological and chemical transformation of plant compounds for production of value added products of therapeutic/aroma value; Bio-prospection of viruses and phyto-plasma and its down stream uses; Novel approaches for detection of incorporated genes in modified GM crops, Molecular approaches for detection and safety contaminants in potable water and food.

The category of Supra institutional programmes comprise : An integrative biology approach in deciphering genotype – phenotype correlation for human complex disorders; Evaluation & correction of Mitochondrial dysfunction diseases; Investigative toxicology: new paradigms; Identification and characterization of contaminants/pollutants/products: environmental and human safety; Enhancing water utilization efficiency in crop plants: Prospecting plant diversity for genes and system biology for drought tolerance; Therapeutic proteins, ultrastable enzymes and other proteins: science, engineering & technology development; and Understanding the molecular mechanism of diseases of national priority: Developing novel approaches for effective management. Inter-agency programmes have been proposed on High through-put and high content screening for bioactive molecules: mining from folk medicine knowledge base and New insight in cancer biology: Identification of novel targets and development of target based molecular medicine. National facilities have been proposed for Functional Genomic Research at IGIB, Setting up a Compact high energy light source for structural analysis of bio-macromolecules at CCMB, Center for Genomics and Metabolomics at NBRI and Advanced Centre for Protein Informatics, Science, Engineering & technology, at IMTECH.

SUPRA-INSTITUTIONAL PROGRAMMES

3.2.3.1 An integrative biology approach in deciphering genotype – phenotype correlation for human complex disorders (IGIB)

The Human genome sequence is a static representation of metabolic and regulatory capability of the cell whereas the phenotype is a dynamic process and represents the status of the cell in a given condition. The correlation of genome variation to phenotype is complex and often non-linear. The most challenging task for the biologists' today is to integrate the various components of this system and to study how perturbation in various gene functions due to genome wide variation can cause imbalance in the system. Such a task would require understanding the various components of the system using an integrative biology approach. In the Tenth Five Year Plan, IGIB had undertaken initiative to develop databases of genetic variations in the genes involved in complex disorders from ethnically diverse normal population. Also by using data mining and pathway in neuropsychiatric disorder as a prototype. Having developed these platforms, IGIB intend to address the following specific objectives using an integrative biology approach.

Research focus

- Identify candidate genes/pathways through data-mining, genome wide expression and proteome profiling approaches.
- Validate genetic variation in the candidate genes.
- Examine Genotype to Phenotype correlation under disease conditions.
- Experimentally validate the effect of gene variants using molecular and biochemical approaches in a subset of candidate genes.
- To develop a genotype to disease phenotype database.
- To develop human resource for integrated systems biology

Envisaged outcomes/outputs

- Identification of promising disease susceptibility genes for schizophrenia, bipolar disorder, cardiovascular diseases & cardiopulmonary conditions
- Development of predisposition markers for the above disorders .
- Locus Specific Disease Database for autosomal dominant cerebral ataxias.
- Development of G2P Database for global platform.
- Specialized (Integrative Biology) man power generation.

3.2.3.2 Evaluation and correction of mitochondrial dysfunction in disease (IICB, Kolkata)

Mitochondria are the powerhouses of the cell, generating ATP to maintain cellular activities. Recent research has sharply highlighted the role of mitochondrial dysfunction in a wide spectrum of human diseases ranging from neuropathies and myopathies, to diabetes and cancer. IICB has diverse and proven expertise in the study of mitochondrial metabolism and the role of mutations in simple and complex disorders, as well as the development and use of animal models for cardiac and neurological disorders. It is proposed to exploit this expertise to study the role of mitochondria in disease, as well as to develop new methods aimed at correcting such dysfunctions.

Research focus

- ➲ To investigate alteration in mitochondrial genes and proteins in primary open angle glaucoma (POAG), using POAG DNA samples and ocular cell models.
- ➲ To investigate mutations in the mitochondrial genome and abnormalities of mitochondrial function in relation to the diverse phenotypes among partients with Wilson's disease.
- ➲ To investigate mitochondrial gene expression and oxidative stress in hypertrophic heart induced by hyperthyroidism excess of anti-inflammatory drugs.
- ➲ To test whether neurodegeneration and mitochondrial decline are correlated in human patients and in animal models of Parkinson's disease and Huntington's disease.
- ➲ To investigate mitochondrial dysfunction in diabetes type 2 with special emphasis on the role of PGCI a and uncoupling proteins.
- ➲ To investigate mitochondria of eukaryotic pathogens as possible targets for correctional measures.
- ➲ To study the role of mitochondrial Reactive Oxygen Species in cancer cell apoptosis and drug resistance.
- ➲ To examine mitochondrial functions in ischemic brain (rat model of neurodegenerative diseases) and delivery of correctional complexes and nanoparticles to such brains.
- ➲ To develop strategies to correct the effects of disease-causing mitochondrial tRNA mutations (e.g. the tRNALys mutation in Myclonic Epilepsy with Ragged Red Fibers) using a tRNA import complex in partient-derived cybrid models, and to study the pathways of the intracellular uptake and targeting of such complexes to mitochondria.

Envisaged outcomes/outputs

- ➲ Methods for diagnosis and treatment of mitochondrial diseases
- ➲ Technology development for drug delivery to the CNS.
- ➲ Understanding the relation between mitochondrial function and disease
- ➲ Knowledge generation, Training of manpower publication and patents

3.2.3.3 Investigative toxicology :new paradigms (ITRC)

Recently threats and use of biological and chemical agents against civilians have exposed their vulnerability and highlighted the need to enhance our capacity to detect and control terrorist acts. The population must be protected from an extensive range of critical biological and chemical agents, including some that have been developed and stockpiled for military use. Even without threat of war, investment in national defense ensures preparedness and acts as a deterrent against hostile acts. Similarly, investment in the public health system provides the best civil defense against bioterrorism. Tools developed in response to terrorist threats serve a dual purpose. These help detect rare or unusual diseases outbreaks and respond to health emergencies, including naturally occurring outbreaks or industrial injuries that might resemble terrorist events in their unpredictability and ability to cause mass casualties (e.g., a pandemic influenza outbreak or a large scale chemical spill). By developing and validating rapid and sensitive biomarkers of toxicity, it will be eventually possible to identify the individuals who could be at risk to the industrial chemicals released in the environment. The development of rapid and sensitive technologies for toxicity assessment and speciation, prediction of the potential toxic effects of the new chemical entities intended for human use based on toxin specific spectrum of molecular responses based on gene expression profiling of target tissues and validation of short term *in vivo* and *in vitro* toxicity screening systems will enable development of appropriate strategies to combat the threat to human health index. The laboratory will serve as the Referral Centre for toxicity assessment of the products of plastic and polymer industries, petrochemical industries, dyes and food color industries, agrochemical industries, chemical industries and pharmaceutical industries.

Research focus

- Mechanism insights and target specific toxicity.
- Low level and long term exposure risk.
- Identify risk factors susceptible to environmental exposures.
- In vivo and in vitro approaches and extrapolations for improved alternative toxicity testing.
- Develop and validate predictive biomarkers (exposure/ effect) to identify "at risk" individuals.

Envisaged outcomes/outputs

- Toxin specific molecular responses.
- Knowledge of systemic toxicity of environmental pollutants at levels generally regarded as safe (GRAS).
- Development of improved alternative toxicity testing.
- Validation of predictive biomarkers (exposure/ effect).

3.2.3.4 Identification and characterization of contaminants /pollutants / products: environmental and human safety (ITRC).

The pollutants and contaminants cause many adverse health disorders and illnesses. An early detection of contaminants and pollutants and removal of these will prevent many health disorders and will be saving many man days in addition to hospital and treatment costs. In addition, dissemination of knowledge will lead to better understanding of environmental and health issues among masses. The techniques/models developed may be used by industries for safety evaluation. ITRC takes active part in institute- industry get together and because of these interactions a number of industries will come forward to avail the services of ITRC which will lead to environmental and human safety to society and industry workers. The knowledgebase generated through this study will help regulatory agencies in formulating guidelines. Molecular probes for contaminants may enhance our capacity to detect and control deliberate acts of terrorism. The main focus in this study will be to achieve early detection and amelioration of adverse health effects due to contaminant/ pollutant exposure through development of newer techniques/models.

Research focus

- Rapid and sensitive technologies for toxicity assessment and speciation.
- Chemical Sensors: Molecular imprinting approach
- Actual human exposure and body burden of environmental pollutants.
- Nanoparticle toxicity assessment.
- Ameliorate toxic potential of xenobiotics by nutraceuticals, herbal products, probiotics etc.
- Dissemination of knowledge on environmental safety and human health

Envisaged outcomes/outputs

- Newer technologies and methodologies for toxicants identification.

- Accelerated toxicity assessment of environmental chemicals.
- Comprehensive toxicological information.

3.2.3.5 Enhancing water utilization efficiency in crop plants: prospecting plant diversity for genes and systems biology for drought tolerance (NBRI).

With global warming decline in the availability of water is being increasingly realized as a serious global threat. In India, a majority (65%) of agriculture is practiced under rainfed conditions. Therefore, crop yields often face serious drought or major reduction in yields due to inadequate rainfall. Water utilization efficiency and drought tolerance vary immensely a midst taxonomic diversity in plants. There is a need to prospect plant diversity for drought tolerance, develop new concepts, tools and protocols for quantifying drought and resistance to drought, understanding mechanistic basis of water utilization and drought tolerance and engineering genes for the transfer of drought tolerance strategies into crop plants. At molecular level drought triggers alteration in gene expression, accumulation of metabolites like abscisic acid or osmotically active compounds, and the synthesis of specific proteins like Lea proteins or reactive oxygen species etc. Thus the effect of drought is not confined to only water relation activities but wide-spread effect encompassing total system of plant. Availability of drought susceptible and tolerant genotypes within a given plant species and the availability of model plants that can be rejuvenated on exposure to water, following prolonged dessication, makes drought tolerance and ideal system for systems biology investigations. A major effort needs to be launched to save the water spent in agriculture and the risks faced by rainfed farming.

Research focus

- Development of quantifiable parameters and efficient protocols for drought diagnostics. Such parameters will be based on developing technologies to monitor plant response to controlled water stress. The studies will lead to the development of high throughput approaches and tools for screening germplasm for the ability to withstand water stress. Such screening will play a valuable role in knowledge-based precision breeding.
- Identifying genes, proteins and metabolites involved in successful plant response to water challenge. High throughput analysis of transcript expression profiles will be used to investigate genetic basis of regulating water response.
- Exploring the mechanism of desiccation tolerance in taxonomically diverse plant species and strategies to survive prolonged water limitation at cellular and organismic level.
- Genetic engineering of model plants, like Arabidopsis thaliana to validate the function of genes discovered for conferring water stress tolerance.
- Developing transgenic of cotton and rice to improve water utilization efficiency and enhance drought tolerance.
- Establishing associated microbes that may contribute to water utilization in plants.
- Developing instruments and tools for drought diagnostics and water management.

Envisaged outcomes/outputs

- Parameters and tools for drought diagnostics and water utilization efficiency.
- Discovery of novel systems for desiccation tolerance in plant diversity.
- IPR on candidate genes for desiccation and water stress tolerance
- Drought tolerant genotypes of a few economically important plant species.

3.2.3.6 Understanding the molecular mechanism of diseases of national priority :developing novel approaches for effective management (IMTECH)

Despite of the availability of several effective therapeutic measures, infectious diseases like tuberculosis, AIDS, malaria, cholera, etc., continue to kill large population of Indians. This extends an urgent need and challenges for the scientific community to understand the molecular mechanisms involved in establishing the infection and development of their effective control measures. The proposed study envisages such activities relating to four diseases of national priority viz. disease mechanisms in tuberculosis, intervention in AIDS: potential vaccines, disease mechanisms in malaria and disease mechanisms in cholera with special emphasis on understanding host-pathogen-interaction; target identification, understanding molecular mechanism and structure function analysis; vaccine development; early diagnosis and development of animal models for disease study. This would lead to the: i) advancement of knowledge in terms of target molecules identified and the strategy defined can be used for the development of technology/know how for diagnosis and therapeutic preventive measures.

Research focus

Focus on activities relating to four diseases of national priorities:

- Disease mechanisms in tuberculosis
- Intervention in AIDS : Potential Vaccines
- Disease mechanisms in malaria
- Disease mechanisms in cholera

Major emphasis will be given to :

- Understanding mechanism of host-pathogen-interaction
- Drug/Vaccine target identification
- Deciphering molecular mechanism and structure function relationship
- Vaccine development

Envisaged outcomes/outputs

- Understanding complex mechanism involved in host-pathogen interaction and disease establishment.
- Identification of the target molecules in above mentioned diseases for immunodiagnostic and therapy.
- Public Goods: 25-30 publications in the journals of international repute.

  Private Goods: 15-20 Patents

  Social Goods: 25-30 PhDs, Trainees: 50-70

3.2.3.7 Therapeutic proteins, ultrastable enzymes and other proteins of importance : science, engineering & technology development (IMTECH)

Since every protein has different physico-chemical characteristics as well as varied conformational stability and behavior, in aqueous environments, a single process developed for a single protein is not applicable to other proteins. Thus, every scientific or technological initiative involving a new protein requires a 'ground-upwards' approach, focused on understanding and dealing with many different aspects of the protein's characteristics. The research programme will encompass the design, generation and testing of a large number of new proteins, including second-generation variants of certain important therapeutic proteins (e.g., interleukin-2, interferon-gamma, erythropoeitin) which require improvement in physico-chemical and *in vivo* characteristics for continued therapeutic usage. It will also involve developing natural forms, protein-engineered forms, as well as chemically-modified variants (e.g., PEGylated variants) of selected therapeutic proteins, a few key thermostable enzymes (proteases, lipases, cellulases, amylases cloned from genomes of thermophiles and hyperthermophiles) and certain other proteins of importance (e.g., bacterial hemoglobins, hydantoinases, FAD synthetases, redox regulators etc) for studies of medical, industrial or fundamental importance.

Research focus

Activity I

Development of Lab-to-Pilot Scale: Expression, Production, Downstream Processing, Purification & Characterization Technologies for Therapeutic Proteins, Enzymes & Other Proteins

Activity II

Structure-Function-Stability Studies of Proteins of Importance

To understand / map / manipulate

- Role of domains, domain-domain and protein-protein interactions with in streptokinase- and staphylokinase-plasminogen complexes
- Role of supersecondary structural elements in regulating kinetics and outcome of folding and unfolding reactions in enzymes and enzyme inhibitors.
- Extent of structure loss, or structural rearrangement, in aggregates of different proteins of pathological importance.
- Binding of metals to enzymes of industrial importance with a view to altering substrate binding behavior.
- Molecular mechanism of FAD synthetase through structural studies
- Binding of heme to bacterial hemoglobins with a view to regulating oxygen tension in cells.
- Regulation of phosphate metabolism in mycobacteria through studies of a PhoP/PhoR two-component regulatory system.

Envisaged output/outcomes

- Development of technology :
  - Upscaling of expression of at least two proteins per year
  - Upscaled production, downstream processing and purification of at least one protein of importance per year
- Advancement of knowledge :
  - Expression, purification, or characterization of a protein of importance
  - 3-5 medium-impact scientific research papers per year
  - Understanding protein structure-formation, stability, and function
  - 5-8 medium-to-high impact scientific research papers per year

NETWORK PROGRAMMES

3.2.3.8 Gene-environment interaction (*CCMB,* IICB, IGIB, CDRI, ITRC, RRL-Jammu)

Virtually all-human diseases result from the interaction of genetic susceptibility factors and modifiable environmental factors, including infectious, chemical, physical, nutritional, and behavioral factors. This is perhaps the most important fact in understanding the role of genetics and environment in the development of disease. While it is clear that common diseases, such as diabetes or cancer, are a result of the complex interplay of genetic and environmental factors, understanding of the 'gene-environment interactions' is only beginning to emerge. Individuals carry genetic variants that increase their susceptibility to certain diseases. By identifying and characterizing gene-environment interactions, CCMB wiil have more opportunities to effectively target intervention strategies. Many of the genetic risk factors for diseases have not been identified, and the complex interaction of genes with other genes and that of genes with environmental factors is not yet understood. Genetic variations do not cause disease but rather influence a person's susceptibility to environmental factors. We do not inherit a disease-state per se. Instead, we inherit a set of a susceptibility factors to certain effects of environmental factors and therefore inherit a higher risk for certain diseases. This concept also explains why individuals are differently affected by the same environmental factors.

Research focus

This proposal seeks to understand the diverse aspects of 'gene-environment interaction'. Individuals carry genetic variants that increase their susceptibility to certain diseases. By identifying and characterizing gene-environment interactions, CCMB would have more opportunities to effectively target intervention strategies. Many of the genetic risk factors for diseases have not been identified, and the complex interaction of genes with other genes and that of genes with environmental factors is not yet understood. India is most suitable country with its variety of human population as well as that of the environment to take up research programme on gene-environment interaction. We have populations/tribes that have not been in touch by modern medicine and represent distinct genotypes that can be used for comparing and exploring the genetic factors that may differentially respond to and interact with a given environmental condition.

Envisaged outcomes/outputs

- Knowledge of gene environment interaction leading to estimation of susceptibility/predisposition to disease/infection
- Predicable drug response paving the way to personalized medicine.
- Greater understanding of genetic basis of development and disease.
- Better understanding the mechanism of evolution

3.2.3.9 Cell and tissue engineering of plants (*CCMB,* NCL, NBRI,RRL-Jorhat,RRL-Jammu, IICT,IHBT)

Cell and tissue engineering of plants deal with tissue culture and plant regeneration and transformation. This programme will be very useful for agricultural applications particularly for improvement of commercially important plants. This study deals with some of the broad topics: such as engineering secondary metabolites in plants; use of plant as bioreactors for production of commercially important molecules; studies on mechanisms involved in plant development and defense response; understanding the signaling events that occur during induction of the innate immune response of rice and characterization of genes that play an important role during early stages of plant development.

Research focus

- Developing strategies for production and isolation of pharmaceutically and commercially important plant compounds using tissue culture and transgenic systems.
- Scaling up existing methodologies for efficient increase in the biomass of commercially important plant/plant tissues.
- Understanding the signaling events that occur during induction of the innate immune response of rice;
- Characterization of genes that play an important role during early stages of plant development.
- Characterisation of colorants and flavourants from plants such as *Amebia euchroma,* Bixa orellana and mango using mass spectrometry/ metabolomics.
- Engineering synthetic rabies surface glycoprotein G gene (rgpG) for high level expression in plants and development of rgpG constructs that have higher immunological efficacy.

Envisaged outcomes/outputs

- Benefits of this program will be in the social and strategic fields because processes developed under the program will be useful for agricultural applications. It is also expected to develop new strategies for isolating therapeutic molecules/colorants flavourants from plants

3.2.3.10 Plasma proteomics: health, environment and disease (*CCMB*, IGIB,IICB,NCL,IICT,ITRC,CDRI,RRL-Jammu,ITRC)

Blood plasma is perhaps the most important body fluid for the integration of biological functions and maintenance of the human body as a system. It contains proteins and peptide originating from different tissues and cells of the body. Quantitative and qualitative changes of plasma/serum proteins and various other metabolic constituents do, therefore, reflect physiological or pathological states of the human body. These can be potentially useful as prognostic and diagnostic indicators of a disease. Understanding plasma protein patterns and their dynamic state would thus be very valuable to identify indicators of normal function as well as the disease state. However, plasma protein analysis poses one of the biggest technological challenge for the biochemists. This is because of the fact that the proteins of blood plasma/serum represent a very wide dynamic range (over 8-10 orders of magnitude) of concentrations. Current advances in proteomics technologies involving protein/peptide separations and mass spectrometry combined with anti body – based methods offer strong prospects of analyzing serum/plasma proteins. An integrated effort of plasma proteomics would closely involve multifarious disciplines such as the science of protein separation, high-resolution mass spectrometry as well as bioinformatics tools useful for data analysis. Such an effort offers an intellectual and technological opportunity to generate information with potential clinical utility. This would involve developing standard and uniform protocols for sample collection, processing of samples in all participating labs and their analysis using different approaches.

Research focus

- To set up, optimize and develop experimental strategies and workflows to carry out comprehensive plasma proteomics of human plasma.
- To explore normal plasma proteome of different population cohorts, tribal populations and its variation with ethnicity.
- To carry out comparative plasma proteomics for diseases using human subjects with clinical conditions and well defined control cohort. The target areas of study would be cancer, cardiac conditions, bacterial and fungal infections, glucose toxicity, environment toxicity.
- To isolate and identify and characterize peptide/protein factors with anti microbial or anti viral property from the blood plasma of Indian mugger.
- To support and integrate with plasma proteomics components of projects under the Gene-Environment interaction network programme being proposed parallely.
- To develop a system for inter institutional electronic transfer of technical data, data management and analysis under the network programme.

Envisaged outcomes/outputs

- Comprehensive basic knowledge about a human plasma proteome.
- Identification of plasma protein markers, if any, for ethnic population groups.
- Identification and development of potential plasma biomarkers for diagnostic or prognostic applications for diseases such as cancer, cardio vascular diseases, pathogenic infections and others chosen for the study.

3.2.3.11 Regulatory RNA in development, health and disease (*CCMB,* IICT,CIMAP,ITRC,IICB,RRL-Jammu)

In recent years non coding RNA molecules have emerged as important tool that cellular machinery uses to regulate gene functions in plants, animals and microbes. Small regulatory RNAs in particular have been found to play a major role in repression of target genes by a mechanism involving RNA–RNA base pairing, referred to as RNA interference, RNAi. Such mechanisms have been implicated in wide range of processes, like, embryonic development, protection from infections, etc. In the context of these new findings in past few years, it has become important to identify full repertoir of non coding RNA molecules as large number of them remain to be discovered, in order to estimate the range of their functional significance. Since the base pairing provides the ultimate specificity that can be achieved in biological systems, RNA based targeting mechanisms are becoming extremely useful in targeting genes of interest to answer questions related to basic biology on the one hand and to be used as 'drugs' to target disease causing genes on the other.

Research focus

(i) generation of RNAi based therapy against infectious diseases; (ii) identification of novel non coding RNAs; and (iii) understanding the role of non coding RNA in diverse nuclear processes like ES cell differentiation, chromatin organization, meiotic silencing, etc. It is also proposed to develop new technologies and create a set up for efficient large scale RNAi applications.

Envisaged outcomes/outputs

- RNAi is an extremely important technique and likely to benefit both applied as well as basic research. This new technology provides means to knock down virtually any gene in any living system and study its function. Owing to these features, RNAi based therapy also promises possible RNA based drugs against cancer and infectious agents including viruses like HIV and JEV.

3.2.3.12 High altitude biology with focus on indian cold deserts (*IHBT*, RRL-Jammu, GBPIHEDA-Almora, ICGEB-Delhi, DRDO-Delhi, HAPPRC-Srinagar)

Indian cold desert, a biodiversity hotspot, is by and large a neglected region for technological development and virgin area for biological research. Therefore there is a need to plan for new strategies to transform cold deserts into functional eco-systems.

A distinct biome with an approx. area of about 1,33,000 sq..km represent a unique ecosystem functioning as a crucible for the evolution of new species complexes in the ecological sanctuaries offered by the greater Himalayan Mountain systems. In view of the severe cold, intense radiation load, varying available moisure levels and low partial pressure of gases, all the living organisms in this region have developed adaptation to these conditions. Due to these climatic condition plants need to carry photosynthesis with very little CO_2, develop radioprotection because of too high UV radiations and produce novel primary/secondary metabolites/aroma chemicals in stressful conditions. Precipitation is only in the form of snow and temperatures plummet to – 45ºC in winters and compression of thermal zones in an altitudinal range of 2000-6000 m give rise to large number of microhabitats inhabiting varied living organisms including plants, animals, insects and microbes.

The present project is proposed to make specialized ecosystems functional for humans though greening strategies and improvement of fertility status of soils,,bioresource utilization for development of agrobased, aromabased, and herbal technology based industries and combating ill effects of climatic changes in coming decades.

Research focus

- Greening strategies and wasteland upgradation.
- Plant adaptation to extreme cold stress.

- Bioprospecting for novel bioactive aroma chemicals and their value addition.
- Impact of climatic changes on Phytodiversity and conservation strategies.

Envisaged outcomes/outputs

- Greening strategies and improvement of fertility status of soils through R&D interventions will contribute towards public good.
- Bioresource utilisation for development of agrobased, aroma based, herbal technology based industries.
- Strategies to be evolved for combating ill effects of climatic changes in coming decades.

3.2.3.13 Exploitation of India's rich microbial diversity (*IMTECH,* NCL, RRL-Jammu, RRL-Jorhat, RRL-Bhub., RRL-Tvm., IGIB, IICT,CCMB,ITRC,NBRI,CIMAP,IICB,IHBT,NEERI,CDRI,IIP)

World wide, 200,000-250,000 bioactives are known of which 22,000-23,000 are microbial metabolites. In addition, there are 20,000-25,000 so called "inactive" metabolites. Only a very small fraction is useful in humans. If one considers that 95% of the microbial diversity has still not be exploited then the number of bioactives is anybody's guess !!. The exploration of microbial diversity, from selected niches all over the country, has given us a brief but tantalizing glimpse of the enormous potential that exists within our country, both in terms of culturable and 'unculturable' (Metagenomic libraries) microbial diversity. This activity has given us a strong base of around 7500 cultures and 25 metagenomic libraries and an impressive number of entirely novel species of microorganisms. This basic platform leads to the next, more applied goal, namely the fruitful exploitation of this biodiversity in a form that makes a major economical impact.

Research focus

- To find microbial metabolites effective against infectious and metabolic diseases. Emphasize "neglected", novel genera from special niches.
- Discover and characterize enzymes with unusual properties.
- Target key (very challenging) biotransformations relevant industrial application.
- Tackle selective environmental problems (Bioremediation).
- Screening metagenomic libraries.

Envisaged outcomes/outputs

- Lead molecules
- Biochemical screens
- Enzyme/enzyme systems with special traits
- Microbial consortia and new metagenomic libraries
- Unusal microflora and metagenomic libraries of extremophiles

3.2.1.14 Engineering peptides and proteins for new generation therapies (*IICB*, IMTECH,IGIB,CCMB,CDRI)

Proteins are by far the functional units of all known life forms. An understanding of their structure, function and interaction is essential for an understanding of life itself. With gradual understanding of proteins and their interactions with other partners, possibilities of engineering new functions are becoming realizable. Engineering new proteins and peptides can usher in a new era in therapeutics and other areas. Major challenges of protein/peptide therapeutics are in the form of inability of large majority of proteins to penetrate cell membranes, poor bioavailability, antigencity and lack of a proper formulation. New techniques of peptide synthesis and semi-synthesis to produce peptides with non-natural amino acids, which are resistant to proteases, are producing peptides of increasing bio-availability. New techniques are being validated for incorporating non-natural amino acids in proteins by manipulating translation process are raising hope of protease resistant proteins and perhaps less antigenicity. In this background a project in engineering of therapeutic proteins of altered properties will be initiated.

Research focus

- To engineer streptokinase's that have weaker immune response.
- Engineer defensins of lesser complexity and enhanced anti-microbial properties
- Design some novel small antimicrobial peptides with reduced toxicity.
- Peptidomimetics with membrane penetration capability to block protein-protein interaction
- Study of protein mis-folding and aggregation through engineered proteins that do not mis-fold and aggregate
- Small peptidomimetics which are equivalent to larger transcription factors
- Designing & Development of recombinant proteins with enhanced stability and reduced toxicity, which can be used to cure certain life-threatening disease

Envisaged outcomes/outputs

- Public Goods : 40-50 papers in high-impact Peer Reviewed Journals
- Private Goods : 8-10 Patents & 2 Licensing out
- Social Goods : 12-15 Ph.Ds and more trained personnel at other levels

3.2.3.15 Pathway engineering and system biology approach towards homologous and heterologous expression of high-value phytoceuticals (artemisinin, taxanes, picrosides, morphine, withanolides, podophyllotoxin)- (*CIMAP*, IHBT,NBRI,NCL,IICB,IMT,RRL-Jammu)

Many of the industrially and commercially used pharmaceuticals are products of secondary metabolism in microbial or plant systems. All the natural/secondary product pathways start as branch points from primary metabolism. Till today in India not a single laboratory possesses EST library representing the full expressed genome of any crop ready for gene expression and regulation analysis. Without understanding the basics of gene regulation it would not be possible to generate designer crops. Study of the major pathways and genes for future chemotype and genotype designing and expressions of the known genes of the pathway for high value phytoceuticals in heterologous system followed by harvesting the intermediates amenable for chemical modification to reach the end product are very much important for designer crops. This study is globally important because worldwide laboratories are networking to generate and analyze EST libraries representing complete expressed genome in different plants of commercial importance.

Research focus

Construction of designer strain of yeast expressing geranyl pyrophosphate, farnesyl pyrophosphate, geranylpyrophosphate and squalling pyrophosphate, ready to clone pathway genes.

Isolation, cloning and expression of available pathway genes from known plant species for

- artemisinic acid [sesquiterpene],
- taxanes (and related compounds [Diterpenes])
- picrosides [iridoid glycosides]
- morphine [benzo-isoquinoline alkaloids]
- Withaferin and Withanolides (Modified triterpenes)
- Podophyllotoxin (glucosides)
- in suitable heterologous expression systems.

- Parallel approach to identify and isolate the unknown genes of the pathways from known and other genetic resources based on bioinformatics approach of gene prospecting and substractive EST approach (Specific Expression Subset Analysis).
- Transgenic plants for strategic genes.
- Real-time expression analysis of known genes in systems vis a vis the metabolites in homologous systems.
- Analysis of heterologous system for expression pattern through Real-Time PCR, proteomics and metabolic profiling towards downstream processing.
- Creation of novel genetic switches for use in synthetic biology.
- Chemical modification of the intermediates expressed in heterologous system or in source plant themselves (semisynthesis approach).
- Scaling-up and harvesting of metabolites.
- Standardization of purification of the compound from the metabolically engineered system.

Envisaged outcomes/outputs

- Efficient ready-to-use expression system in yeast for introduction and expression of key terpene genes of commercial importance.
- Efficient and controlled key metabolite-expression systems providing economic edge over the traditional source of the phytoceutical.
- Annotated EST bank for the important pathway occurring in Withania somnifera, Artemisia annua, Papaver somniferum, Podophyllum sp. and Picrorrhiza kurroa.
- Structural and regulatory genes from the above plants.
- Transgenic yeast, mushrooms, plants with high expression of metabolites for harvesting on large-scale.

3.2.3.16 Biological and chemical transformation of plant compounds for production of value added products of therapeutic/aroma value (*CIMAP*, RRL-Jorhat, NCL,IICB,RRL-Bhub,IICT)

Plant systems offer a large number of enzymes for conversion of substrates to desirable products considering the genome size and metabolites produced. The number of these enzymes are beyond imagination as the complete metabolic pathways for innumerable metabolite biosynthates are far from being deciphered. Most of the enzymes used for bioconversions are of microbial origin and limited in number. So enzymes from plants offer diverse, complicated bioconversions compared to the microbes. The project envisages conjugative types of chemical and biological transformations with major focus on chemical dimerizations, chemical linkage of small molecule side chains (semisynthesis), chemical coupling of peptides, biocatalytic acylation (acyl transferases) and glycosylation (glycosyltransferases/glycosidases) of phytochemicals of pharmaceutical and/or aroma value. The functionalities of advantages aimed to be achieved through the chemical or biological transformation involve altered polarity and volatility, better organoleptics, better stability, enhanced water solubility and better pharmacokinetics and enhanced efficacy/imparting newer biological activities.

Research focus

- Identification, isolation and characterization of bio-catalytic (glycosylation & acylation) capability of plants and microbes for their sustainable exploitation.
- Development of chemo- and biotransformation systems directed towards selected phytochemicals and phytopharmaceuticals for their biological activity diversification and/or enhancement.
- Building up of a biocatalytically & structurally characterized gene stock of the biocatalysts (like GTases, AATs) active on diverse phytochemicals.
- Cloning of selected genes in suitable microbe (E. coli) for use in the defined and productive biotransformation in vivo & development of immobilized (cell /enzyme) biotransformation system.
- Designing of sequential catalysis biotransformation system by additive up-stream activities (like synthase, methyl transferase, hydroxylase etc.).
- Chemical transformations of anticancer-(taxoids polyisoprenylated benzophenones) and hepato-protective (coumarino-lignoids, flavanolignans) molecules for enhancement of activities and water solubility

Envisaged outcomes/outputs

- Biotrasnformation mediated value additive (e.g. aq. Solubility, volatilty, fragrance) modification of plant compounds
- New biocatalysts and their genes, and New Bio/Chemicals and Processes
- Knowledge base on AATs, GTs and glycosidases.
- New Targets and tools for metabolic engineering of pathways.
- Production of chemically transformed novel phytopharmaceuticals.
- Novel molecular variants on a skeleton for SAR.
- In vitro immobilized cell and enzyme based biotransformation process.
- Comparative description of metabolic diversity w.r.t. substrate specificity (structural, stereo- and linkage)

3.2.3.17 Bioprospection of viruses and phytoplasma and its down stream uses (*IHBT*, NBRI,CIMAP,CEERI)

Plant viruses and phytoplasma cause severe diseases due to which production of crops is greatly reduced and ultimately they affect the economy of our country. Viruses are nanoparticles and generally transmitted by vectors like whiteflies, aphids, thrips, mites, fungi and nematodes etc. Disease losses to the agriculture crops are almost 21% and among them viruses constitute about 1/3 of them. Viral diseases can be managed by vector control, eradication of weed and other virus reservoirs/ hosts, sensitive detection of viruses at early stages and development of virus resistant plants. This study will further strengthen the capabilities of the respective CSIR laboratorfies.

The generated data would be helpful in value addition for the domestic as well as export oriented Agro-horticulture produce and will also ease the quarantine regulations.

Research focus

- Understanding genome organization, assessment of variability (groups to be covered Tricho,Ilar, Poty-, CMV, Begomo-) and development of diagnostics through nanobiotechnology (IHBT, NBRI, CIMAP, CEERI)
- Understanding host pathogen interaction in case of Cucumber mosaic virus (CMV)
- Yeast based strategies to develop constructs to control plant virus infection
- Designing and testing of promoters for plant transformation (IHBT)
- BYMV nanoparticles as oral delivery agents;
- Development of virus-resistant cotton plants against cotton leaf curl disease.

Envisaged outcomes/outputs

- Viral diagnostics including microchips for virus detection and strain identification
- Understanding the process of suppression of silencing by CMV which can be used later for control of the virus
- Step towards developing tool for virus control
- Alternate and stronger promoter for use in transgenic plants
- BYMV-based expression vector and BYMV nanoparticles based delivery agents for anti-rabies vaccine
- DNA sequence of β, DNA-1, DNA-A components of CLCuD
- CLCuV specific diagnostic probes
- Transgenic cotton plants with replicase, coat protein and DNA β genes for CLCuD
- Genes responsible for viral infection will be identified for viral disease management.

3.2.3.18 Novel approaches for detection of incorporated genes in modified GM crops (*ITRC*, IGIB,NBRI)

Since, consumers are concerned about the use of genetically modified crops in food production, many food producers and food suppliers offer foods whose identity shows them to be from crops that are essentially free of GMOs. In this situation, labeling and to develop baseline data for detection of GM foods has become more important and necessary and GMO labeling regulations are in force. So far all imports of transgenic planting materials and seeds are through a single window i.e. National Bureau of Plant Genetic Resources (NBPGR) under ICAR, New Delhi. To check the import of unauthorized GMO's the effort in this direction will be very helpful in safety evaluation and detecting the GMO beforehand.

A baseline data, about GM Genes and their easy detection, will enable us to handle detection and safety of new GM crops, being developed globally and brought to India for the commercial purpose and also the one being developed in the country for safer export.

Research focus

- Identification of available GM food crops using recent DNA based molecular biology techniques.
- Development of chip-based diagnostics for the detection of GM foods and to assess their safety evaluation.

Envisaged outcomes/outputs

- A baseline data, about GM Genes and their easy detection. This will enable us to handle detection and safety of new GM crops for import/export.

Public Goods:	20-25 papers
Private Goods:	3-5 patents
Social Goods:	3 – 5 Ph.Ds, 50 summer trainings
Product Development:	2-3 Diagnostic chips

3.2.3.19 Molecular approaches for detection and safety: contaminants in potable water and food (*ITRC*, CFTRI,IGIB,NEERI,NPL)

Rapid urbanization and population growth has caused extensive morbidity and mortality due to unsafe water and food in rural and urban environment. It is time to move to risk based testing methods and regulation of water and food supplies. By developing and applying new tools to identify and detect pathogens and other contaminants in low doses, the problem of contamination in water and food may be dealt more effectively.

Research focus

- To develop real time polymerase chain reaction and nanoparticle probes for detection of pathogens in potable water and food
- To develop DNA and protein based detection and allergy assessment methods for GM Foods
- To develop LC-MS and protein based methods for food contaminants and adulterants.
- To develop framework for risk characterization based on exposure assessment

Envisaged outcomes/outputs

- Optimisation of protocols for (i) Extraction of pathogen DNA from food and water samples (ii) PCR reactions
- Validation of probes for reference strains and real-life samples.
- Database for Genetic sequences validated for probe design and available probes.
- Indigenous protein and DNA based test kits for GMO HPLC/ ELISA methods for mycotoxins in food commodities.

INTER-AGENCY PROGRAMMES

3.2.3.20 High through-put and high-content screening for bioactive molecules: mining from folk-medicine knowledge base (*IGIB,* Honey BEE Network-Ahmedabad, NIF, TCGA-New Delhi).

Bioactive molecule discovery from plants based on traditional knowledge of Ayurveda, Siddha and Unani has be undertaken by CSIR. Folk medicine offers a rich and exclusive resource for India. Honeybee network has a large depository knowledge on folk-medicine generated by the people of India who are not even formally educated. IGIB is to establish a

“People’s Incubator” at IGIB (CSIR) as a part of the CSIR bioactive molecular programme . It is of the strategic advantage to take this knowledge to a robust and reliable level for mass treatment. The present proposal aims to interface this folk-knowledge with high-throughput chemical processes, output of which will be taken through high-content screening for discovery of bioactive molecules across more than 100 assays cell based, antimicrobial including bio-availability and biologically relevant parameters.

IGIB brings in strong knowledge for conceptualization of strategies in the light of human genetic and infectious disease and in silico analysis for druggable targets. Honeybee programme (Srishti**)** provides the valuable source of folk knowledge and the plant resources many of which are not available in written knowledge resources. TCGA/TCG Life Sciences bring in high capacity for isolation and screening, with more than 100 cell-based available in-house.

Research focus

- High-throughput extraction from natural flora and fauna based on proven application in folk medicine to create a large repertoire of bioactive extracts and fractions.
- High throughput screening/profiling of natural product extracts using panels of assays already available with TCGA.
- Development of novel high throughput/high-content screens using system biology approach and the leads from the various genomics and proteomic initiative by IGIB-TCGA
- High throughput validation and discovery of novel small molecules/ chemical entities from extracts provided by NIF.

Envisaged outcomes/outputs

- The establishment of a repository of assayed fractions and novel bioactive molecules from natural flora and fauna utilized in folk medicine leading to the creation of “Peoples’ Incubator “.
- The screening results in turn feeding design of novel assays for bioactive molecules, which will be unique in combining folk-medical knowledge and modern tools of cell and molecular biology for wider applications.
- Potential to take folk medicine to a robust and reliable level for mass treatment.
- Standardisation and validation of at least 2-3 folk medicines.
- Generation of IPRs shared with grassroots innovators.

3.2.3.21 New insights in cancer biology : identification of novel targets and development of target based molecular medicine (*IICB,* IGIB,CCMB,CDRI,IICT,CGCRI,NCCS-Pune, JNCASR-Bangalore)

A number of cell signaling molecules, cell-cycle regulators, metabolic enzymes and cell surface macromolecules are currently considered as potential targets for the development of novel therapeutic agents for cancer treatment. Despite this, a continuing effort to identify new molecular targets based on the knowledge drawn from the molecular analysis of cancer cell lines, primary tumor tissues and non-human cancer models will enrich the repertoire of new molecular targets. Furthermore, capability of high-throughput screening, development of newer chemistry to synthesize hundreds of compounds in short time and knowledge based designing of new compounds have given unlimited opportunity to develop newer anticancer therapeutics.

Indian Institute of Chemical Biology (IICB) has generated tremendous amount of knowledge in cancer biology using various cancer model systems relevant to India. The breadth of the knowledge ranges from the basic understanding of oncogenic processes operating in the incipient tumour cells to the development of new anticancer molecules from herbal sources and sensitive detection techniques for residual leukemic cells. It is a high –throughput approach in a network format to identify lead molecules from herbal and chemical sources that can interact with one or more key cell signaling molecules, cell cycle regulators, enzymes and cell surface macromolecules leading to cell cycle arrest and adoptosis.

Research focus

- Molecular Analysis of Tumor Cells
- Development of Animal Models for Cancer
- Lead Molecules for Specific Targets
- Exploration of Biodiversity in Eastern India

Envisaged outcomes/outputs

Public Goods:	-	60-75 publications
	-	5-10 novel targets for future evaluation
	-	New insights in tumorigenic mechanisms
Private Goods:	-	10-20 lead molecules
		At least 1-2 licensing to pharmaceutical companies
Social Goods:	-	New therapeutic strategies
	-	Better patient management

NATIONAL FACILITIES

3.2.3.22 Facilities for functional genomics research (IGIB)

As a verterbrate animal, zebrafish is more closely related to humans than yeast worm or fly. Zebrafish have number of advantages that make them an attractive model system to study vertebrate development, disease and regulatory pathways. Among the several advantages, perhaps the most striking is the inherent conservation of genes and biological processes specific to vertebrate development. A large number of zebrafish genes share a high degree of functional and structural similarity to their human homologous. In addition, genomic tools for manipulating zebrafish are constantly under development. Zebrafish are also amendable to a large –scale mutation screen as exemplified by the fact that several forward genetic screens have been undertaken and a large number of mutants have been successfully isolated. Even though chemical genetics continues to represent the most common technique utilized in zebrafish genetic screens, strategies for insertional mutagenesis using retroviral vectors or transposable elements have emerged as powerful approaches. In particular, the transposon-based system provides several attractive features such as ease of vector preparation and the ability to remobilize an existing insertion provides a potentially renewable resource for ongoing mutagenesis.The zebrafish facility at IGIB would serve as a central repository for wild type, mutant and transgenic strains of zebrafish for functional genomics research.LC-NMR is a state-of-the-art analytical platform widely applicable to complex mixture analysis. LC NMR technology is mostly used for separation and characterization of biomolecules, such as small proteins, peptides, DNA and recombinant products because of its high efficiency and excellent resolution. Coupling separation technology (LC) with spectroscopic technique (NMR) is of great help in quantitative and qualitative analysis of unknown compounds in complex matrices.

The zebrafish facility at IGIB would serve as a central repository for wild type, mutant and transgenic strains of zebrafish for functional genomics research.

i. Cellomics facility for functional genomics research.

Aim of the facility

- High throughput and high resolution in vivo image based cellular screening for in-depth understanding of biological processes.
- High-throughput, non-destructive, multiplexing assays at the cell population and sub-cellular level, deriving inputs from high-quantity activities for monitoring intercellular events in context of its environment (in-situ).
- High throughput in vivo functional validation and discovery of novel small molecules/ chemical compounds.
- High-throughput functional analysis (in cell culture, Drosophila or Zebrafish models) of plant extracts obtained from Indian traditional medicinal system leading to holistic and improved therapeutic drugs.
- In vivo expression profiling of human disease models (cell culture, Drosophila or Zebrafish models).

Envisaged outcomes/outputs

- Establishment of a high-resolution, high-throughput imaging system that is capable of utilizing multi-colour fluorescent molecules in live cells/tissues.
- A platform for integrating information from high-quantity assays such as functional genomics, proteomics, micro arrays and *in-silico* biology for understanding complex biological processes.
- Establishment of a high-throughput platform for whole cell/animal based *in vivo* assays.
- Establishment of a high-throughput platform for *in vivo* functional analysis of plant extracts from Indian traditional medicine system.

ii. Zebrafish facility for functional genomics research

Aim of the facility

- Generation of transgenic zebrafish lines for functional genomics research.
- Forward genetic screens with particular emphasis on identifying genes involved in adult specific diseases.
- Reverse genetics screens to generate "knockdowns" of candidate genes that have biomedical applications.
- High throughput *in vivo* functional validation and discovery of novel small molecules/ chemical compounds.
- A central repository for wild type, selected mutant and transgenic strains of zebrafish for functional genomics research.

Envisaged outcomes/outputs

- Generation of transgenic zebrafish for in-house functional genomics research.
- Generation of a panel of zebrafish with insertions in biologically important genes.

- Generation of zebrafish models of human diseases/biological processes.
- Establishment of whole animal based high-throughput *in vivo* screens.
- Establishment of a central repository for wild type, mutant and transgenic strains of zebra fish.
- Human resource development: Manpower generation in the field of zebra fish functional genomics research.
- Advancement of knowledge: 8-10 scientific publications are expected

iii. LC-NMR facility for functional genomics research.

Aim of the facility

- Peptide and protein structure elucidation.
- Validation of peptide structure/conformation proposed by *in-silico* tools.
- Introduction of metabolomics study coupling LC-NMR and LC-MS technology.
- For identification of novel active molecules from diverse complex mixtures.
- Development methods for screening drug candidates.
- Pharmacokinetics study.

Envisaged outcomes/outputs

- Capacity building in the field of NMR technology.
- A complement for the existing proteomics facility at IGIB.

3.2.3.23 Setting up a compact high energy light source for the structural analysis of biomacromolecules (CCMB)

Structure-based drug design against pathogenic organisms is a major focus of research both in academia and industry. In the post-genomic era, with the availability of genomes of several pathogenic organisms, efforts are already on in using the structural information to aid in determining the function of gene products and to use the information for the design of inhibitory molecules that can be tested for their usefulness as a drug. Global as well as national efforts, particularly in the case of *Mycobacteium tuberculosis*, are underway to determine all the structures of proteins coded in the genome and their complexes with substrates, inhibitors etc. from pathogenic organisms using X-ray crystallography. A very high resolution structural information is required to use them for structure-based drug design. Furthermore, efforts are also on to determine the structures of huge macromolecular machines, multidomain proteins, protein complexes, protein-DNA or protein-RNA complexes etc. These require the use of synchrotron radiation to study crystals to obtain not only high quality data in most cases but also usable data for some others. While we, in the country, lack such a functional synchrotron facility for studying biomolecular crystals, it is a common practice in several countries including in Europe, U. S. A., China, Brazil etc. and some of them possess multiple facilities. Therefore, the requirement for a fully functional synchrotron in the country cannot be overstated in the current scientific scenario. A fully functional CLS facility will tremendously improve the capability of CSIR laboratories towards drug design using structural information against pathogenic organisms.

Aim of the facility

- Setting up a CLS facility in CCMB
- Dedicated beamline for data collection using CCD on macromolecular crystals

- User facility for crystal handling and storage
- Accelerate structural work on important proteins from M.tb and different cellular processes.
- Explore the possibility of SAXS and small molecule structural characterization.

Envisaged outcomes/outputs

- High resolution structural information on several M.tuberculosis and other proteins
- Complex crystal structures for optimization on inhibitor design as drug candidates
- Capability to handle multi-domain protein, protein-protein, -DNA, -RNA complexes, membrane proteins etc.
- Develop expertise in data collection, reduction, beamline management.

3.2.3.24 National center for genomics and metabolomics (NBRI)

National Botanical Research Institute proposes to establish a 'Center For Genomics and Metabolomics' at the Institute to catalyze the development of knowledge- based partnerships with other organizations in semi-business like operational mode. In its minimal scope, it will run various facilities at optimal efficiency in interest of public research institutes and national agenda, within and outside CSIR.

i. GS- MS coupled stable isotope ratio mass spectrometer (SIRMS)

Aim of the facility

- Plant research: water use efficiency, carbon allocation, water sources used by plants, nitrogen cycling, carbon cycling and photosynthetic pathway determination.
- Pharmaceutical Industry drug counterfeiting and process patent infringement.
- Forensic science: documents and counterfeit currencies, drugs and other controlled substances, tracing human movements, commercial and military explosives and pathogenic microbes.
- Food Web Studies: check adulterants like corn syrup in cheap beer, liquor, honey, jams and jellies.

ii. NMR Center for plants and animals

Aim of the facility

- Magnetic Resonance Imaging (MRI)
- Qualitative and quantitative measure of metabolites in intact plan
- Xylem and phloem flow, cavitations, embolisms, drought related studies
- Mapping of the distribution of metabolite in special structures e.g. oil canals
- Infection at anatomical level e.g. xylem blockages

LC-NMR-MS:

- High throughput Metabolites measurements
- Complex metabolic flux measurements

iii. Multidimensional Protein Identification Technology (MudPIT)

Aim of the facility

- Integral membrane, basic and low molecular weight proteins, low abundant soluble proteins
- Whole proteome analysis

- Identification of interaction partners in pathway illucidation
- Post-translational modifications
- Membrane proteomics

Envisaged outcomes/outputs

- CSIR service provider for technology development.
- To establish as an enterprise generator.
- The Center will function on a business model with ten years win-win plan with a large industrial partner for advancing into globally competitive high technology services, contract research, product development and discovery

3.2.3.25 Advanced center for protein informatics, science, engineering & technology (IMTECH)

The physico-chemical characteristics and behaviors of proteins vary widely. The experience in handling a single protein over a few years, with a modicum of success – can often turn out to be completely at sea while having to handle a new protein with a different isoelectric point, different folding and aggregation behavior, different stability, structure and function, because every protein is like a different animal. Whereas molecular biologists who have worked with DNA from one organism switch with great facility to doing similar work with DNA from another organism. Such a switch for a protein researcher is an experience that can be more challenging by several orders of magnitude. IMTECH has gathered a formidable amount of expertise and facilities and to give all this the right shape and take it forward into the future through this center .Protein-based products are the ultimate in terms of low-volume and high-margin and, therefore, the ultimate in terms of cost-benefit analysis. The protein-based technologies, and domain expertise, are so difficult to come by that services in this sector are very renumarating Thus setting up this center makes eminent economic sense. Further, the time taken in scaling up fundamental research to application-mode and in scaling up technologies from research grade to production grade is the smallest for protein S&T.

Aim of the facility

- Establishing under a single roof (i.e., within a special building) the necessary expertise, instrumentation and facilities for research by both institutional and guest workers, in independent and collaborative modes, for work in the areas of:
- Protein Informatics, Protein Bioinformatics, Protein Engineering, Protein Biophysics, Biochemistry and Physical chemistry, and Ready link-up with protein technologies

Envisaged outcomes/outputs

- Setting up of an advanced center incorporating all strengths
- Consolidation of domain knowledge, expertise, and equipment in facility-mode
- Dissemination of knowledge and expertise
- Research: Various aspects of structure, function, design and redesign
- Development: Processes for the production, downstream treatment and purification
- Training: Workshop, consultancy, teaching

Total Plan budgetary requirement projected for the Sector is Rs. 700 crore

3.2.4 CHEMICAL SCIENCES & TECHNOLOGY

Chemical science is indeed an enabling link cutting across almost all service areas. Areas such as new materials, biotechnology, agriculture and food, require an increasingly detailed understanding of the molecular world provided by the chemical sciences. Sustainable progress in health care, environmental protection and wealth creation are all dependent on advances in chemical sciences and engineering. Indian chemical industry has been an integral component of the Indian economy. It is one of the fastest growing sector. The Indian Chemical Industry in the year 2005 had a 14 per cent growth in sales with the net profit increase of 18 percent. One of the major reasons for the upswing of the Indian Chemical industry is the increase in exports. In the year 2005-06, US$ 3 bn worth of organic, 0.5 bn inorganic, 0.4 bn pesticides and 0.6 bn worth of dyes were exported.

CSIR has traditionally been very strong in Chemical sector. CSIR labs have developed technologies for a host of bulk as well as fine chemicals with emphasis on developing green technologies. CSIR has contributed remarkably to the production of agrochemicals. At one point of time, almost 70% of the pesticides produced were based on CSIR technologies. In the 11th Five Year Plan, a more focused and concerted effort is envisioned to exploit the gains made during earlier plans by pooling in resources and expertise available in various CSIR labs.

The programmes proposed for Eleventh Five Year Plan broadly cover the emerging areas: two suprainstitutional projects 'Enabling science for building specific R&D capabilities' and 'Competency building through creation of centres of excellence' aim to develop core competency of the respective laboratories while enhancing intranetworking within the lab; creation of **NCL-IGIB Center** which aims to bring together excellence in biological and chemical sciences for better and faster delivery of processes/ products under networking; ten proposals under networking mode, viz;(i)Development of new adsorbents and membranes for potential application in separation technologies;(ii)Development of specialty inorganic materials for diverse applications, (iii)Fluoroorganics by chemical / electrochemical methods, (iv)Agrochemicals and intermediates;(v)Design and development of nanostructured materials for biological applications;(vi)Biologically active compounds through catalysis, (vii) functional organic materials for photonic, electronic and opto-electronic applications;(viii)Design, development, in vitro and in vivo studies of novel sensitizers for Photodynamic Therapy (PDT);(ix) Development of gas to liquid (GTL) processes for DME and Fischer-Tropsch fuels for pooling competencies and resources of various labs within CSIR, (x)NCL-IGIB centre

Creation of a facility 'Center of Excellence for Lipid Research' is proposed which aims at addressing issues related to vegetable oil industry of India. In the succeeding paras, brief details of the proposed proposals are presented. The deliverables identified in italics represent either entirely new chemical entities, new processes involving new raw materials, or new initiative to understand science which may lead to disruptive technologies and are expected to make significant impact.

SUPRA-INSTITUTIONAL PROGRAMMES

3.2.4.1 Enabling science for building specific R&D capabilities (CSMCRI)

For deeper understanding of the scientific phenomena relevant to the activities of the lab, CSMCRI has proposed this suprainstitutional project for deeper scientific understanding which may become a source of future technological opportunities, source of new interactions/networks, technological options, hence increasing technological diversity.

Research focus

To further enhance knowledge and competency in existing areas:

- fundamental studies on the crystal habit modification of sodium chloride using additives
- studies on the shape selective host–guest interactions in supramolecular complexes
- spectroscopic understanding of the thickness of thin film composite (TFC) membrane coating
- polymer synthesis to develop a new class of solvent resistant membranes having implications in diverse industrial sectors.

Understanding of crystallization of calcium carbonate:

- user-friendly rapid method for detecting toxic trace ions in water
- crystal engineering of organic salts to design and synthesis of gelling agents
- hydrotalcite crystallization and its structure to develop new forms of stable micronutrient delivery systems
- zeolite crystallization and pore engineering for novel adsorbents for gas separation

Core competency in coordination/redox chemistry of eco-friendly brominating agent and new approach to eco-friendly synthesis of styrene oxide

Envisaged outcomes/outputs

High quality research publications, generation of new knowledge/ ideas and applied Research focused on improvements in competitiveness of technologies in following areas of chemical sciences:

- Co-ordination chemistry and catalysis
- Solution chemistry and phase equilibria
- Crystallization and crystallography
- Organic synthesis and polymer chemistry
- Membrane and adsorption science
- Understanding of seaweed polysaccharide gels and organic salt-based gels
- User-friendly analytical techniques

3.2.4.2 Competency building through creation of centres of excellence (NCL)

The proposal envisages creation of several intradivisional research units within NCL for excellence in areas of emerging relevance and importance to chemical sciences. These units will focus on specific areas such as computational chemistry, process intensification using microreactor engineering, crystallization and polymorphism, surface science and engineering, separation science and technology and optical scattering.

Research focus

To create following Centres of Excellence to remain relevant and become globally competitive

(i) Computational Chemistry: An Integrated Tool for Multi-Scale Simulation to Design
(ii) Surface Science and Engineering
(iii) Separation Science and Technology
(iv) Optical Scattering Phenomena and its application to soft Condensed Matter Research
(v) Drug Polymorphism and Supramolecular Structural Chemistry
(vi) Process Intensification using Micro Reactor Engineering

Envisaged outcomes/outputs

(i) Computational chemistry: An integrated tool for multi-scale simulation to design

- Design of materials with desired functionality
- Intellectual property creation in term of new softwares
- Design of new products based on scientific computing strategies
- Optimization and operation of new plants based on process development
- Optimization in process operating conditions and novel strategies leading to improved performance
- Computational chemistry based de novo drug design
- Virtual universe creation in the chemical space where known chemical entities and their precursors would be analyzed to generate new chemical entities for exploration of scientifically relevant data for drug discovery
- Access to Chemical and biological related data through single portal
- Integrated Chemical and Biological Data Grid

(ii) Surface science and engineering

- Technology packages for products based on interesting surface patterning, design and modifications. Other possible areas: Specialty coatings, diagnostics, medical products, and catalysts. Emphasis will be on surface engineering methods and surface engineered products.
- New capacity building: Specialized surface patterning techniques like ink jet manufacturing, micro- and nano-patterning of surfaces for tailoring biological activity, developing sensors and diagnostics.
- New research, characterization & sample fabrication facilities: Imaging and analysis of surfaces at various scales from atomic to microns. Measurement of surface properties and surface phenomena like friction, wear, conductivity etc. Techniques for engineering surfaces Ink-jet patterning and deposition techniques. An ink jet patterning facility will be unique to India.
- Research and consulting support for industry: The Centre is likely to interact with the following industries -- Paints, coatings, polymers, biomedical products, various industries involving catalytic processes.

(iii) Separation science and technology

- Specific technology packages in the form of separation process, software and hardware requirements may be delivered

(iv) Optical scattering phenomena and its application to soft condensed matter research

- CEST will be a unique experimental facility of international standards in India, a first of its kind for soft material characterization from nano to micro scale. Non-invasive techniques like Optical Microrheology will help in better understanding the rheological properties of soft materials. Instruments like 3D-Dynamic light scattering will help in characterizing materials under turbid conditions- a situation generally encountered in industrial samples.

(v) Drug polymorphism and supramolecular structural chemistry

- Novel polymorphs of several API's of drugs, supramolecular assemblies of exotic properties with applications in pharma and materials areas

(vi) Process intensification using micro reactor engineering

- Enhanced interaction between NCL and the domestic as well as international chemical industry.
- Computational and experimental tools to characterize flow, mixing and reactions in micro-channels.
- New insights into multiphase flow, mixing and reactions in narrow channels.
- Development of new micro-devices and components on micro-chemical plants (mixers, heat exchangers and reactors).
- Identification and analysis of new ways of integrating separation processes in micro-plants.
- Unique facilities and expertise on designing and developing micro-plants/ micro-devices.
- Trained manpower for practicing microreaction technology with skills of using the microfabrication techniques.

(vii) Lab to industry facilitation center

- Creation of scale up / product validation capability in tune with modern requirements
- Information important to control the process or regain control of it (Reaction kinetics, Heat and mass balance, Thermal stability & hazard analysis, Heat capacity determination)
- Maximization of yields.

(viii) Ultra high field NMR facility

- State-of-the-art NMR facility
- A resource center for promotion of interdisciplinary research
- Genration of trained manpower to cater emerging requirement of skilled manpower in the field

NETWORK PROJECTS

3.2.4.3 Development of new adsorbents and membranes for potential application in separation technologies (*CSMCRI,* NCL, and IICT)

While membrane research has become a important area of R&D for CSIR during last one decade with tremendous progress made on developing Reverse Osmosis (RO) and Electro Dialysis (ED) based separation processes, there has also been continuous effort on development of inorganic and polymeric adsorbents to achieve separations of racemic and other difficult to separate mixtures. The competencies developed by various laboratories in different areas of separation product development will be synergised under the envisaged proposal to provide indigenous cost effective and commercially viable separation technologies.

Research focus

- To develop more competence and expertise to develop membranes for separation processes
- To develop new inorganic/ organic adsorbents for separation of difficult to separate mixtures.
- To provide indigenous cost effective and commercially viable separation technologies.

Envisaged outcomes/outputs

Membrane research:

- Membrane/adsorbent based separations having industrial utility
- Develop ultra-filtration and nano-filtration membranes with tight pore size control, both in hollow fibre and spiral wound configurations
- Develop TiO_2 or silver nano particles doped polymeric (PSF, PES, PAN or PVDF) fouling resistant membranes
- Develop thermally stable and organic solvent resistant polyimide-montmorillonite nanocomposite membranes for applications in lube oil processing, dephosphorilization of vegetable oils, and separation of alkenes from alkanes
- Develop thermally stable ion-exchange membranes for high temperature electro dialysis applications
- Develop diverse portfolio of resins for applications in brine purification and separation of natural products
- Development of solvent resistant ultrafiltration, nanofiltration and pervaporation membranes.
- Development of advanced functional UF and NF membranes for chemical and bioseparations
- Development of acid and alkali resistant NF membranes.

Adsorbent research

- Develop chiral adsorbents for separation of enantiomers
- Development of zeolites, clay and silica based adsorbents of control release of fragrance molecules like rose oxide, jasmine
- Improve further the gas separation properties of zeolite adsorbents already developed and extend the scope of application to gaseous mixtures namely CO/N_2; CH_4/N_2; CH_4/CO_2
- Integrate work on trace moisture removal with zeolites with biodiesel process and use of hydrotalcite for sequencing of pollutants and micro nutrient

3.2.4.4 Development of specialty inorganic materials for diverse applications (*CSMCRI,* IIP, RRL,RRL-Trivandrum, NML,RRL, Jorhat, CECRI)

Advanced materials are precursors to the development of new technologies. Over the last decade and half, molecular designing of the new materials is possible due to better instrumentation to probe materials and deepened understanding of the mechanisms that control molecular architecture. Various CSIR institute working in the area of inorganic materials have made a substantial contributions in the area of specialty inorganic materials such as zeolites, clays, silica, hydrotalcite and specialized materials like MgO, zirconia, modified TiO2, nano hard coatings of TiN on steel etc. It is proposed to build on the existing expertise to design and develop new materials for specific applications. These materials will be basically nano-inorganic materials which will be useful for catalysis, adsorption and preparation of nanocomposites.

Research focus

- To develop nano-structured inorganic materials, nanoclays, nanoporous materials, nanocomposite materials, functionalized silica materials for diverse applications
- Modified TiO_2 surfaces based materials for photovoltaic applications.

Envisaged outcomes/outputs

- Nano-Inorganic materials for methane , H_2 storage, catalysis, adsorption and preparation of nano-composites
- Functionally graded nanocomposite membranes based on pervoskite structured ceramics for hydrogen separation
- Surface Functionalized silica and titania for anchoring of specialty ligands for metal recovery and photovoltaic applications.
- Synthesis of nano titanium oxide(TiO_2) and titanium zinc oxide films for dye sensitized phototelectrolysis.
- Develop ceramic coatings on steel surfaces based on SiO_2, Al_2O_3 and ZrO_2 through sol-gel route
- To develop nanoclays for applications in for polymer nanocomposites, paints, inks, grease and cosmetics formulations, drug delivery vehicle and waste water treatment
- To synthesize ultra pure Cu, Ni and Co powder (99.99% purity) through chemical route
- Design & synthesis of hybrid calixarene receptors anchoring amino acids/small peptide chains/carbohydrate moieties for molecular recognition
- Design and synthesis of Ferrocenyl calixpyrrole and calixphyrins and study their receptor and electrochemical sensor properties.
- Develop specific anion imprinted polymeric materials for sensing and detoxification of these anions
- To develop nitrogen and ammonia sensors based on incorporation of mixed oxide system $MoO_3 - WO_3$ films.
- Preparation of magnesium indium oxide($MgInO_4$) and magnesium zinc oxide films for transparent electrodes in liquid crystal displays and lithium intercalation.
- To develop hard coatings of Titanium Aluminium Nitride(TiAlN) by reactive sputtering technique for protective applications.
- Nanoscale synthesis of high purity MgO and ZrO_2 based specialty materials from refining and catalytic applications
- Fabrication of dye sensitized photoelectrolysis cells with the mixed titanium zinc oxide films

3.2.4.5 Agrochemicals and intermediates (*IICT*, RRL-Jorhat, IHBT)

CSIR laboratories have developed strong base of Organic Synthesis and preparation of New Chemical Entities and Lead Generation. They have established strength in developing pesticide technologies/ commercialization. The labs have proven capability in isolation – characterization of new plant based natural products and developing technology for the enrichment of pesticidal active ingredients CTC formulations (product standardization). The competencies available in these labs are capable of developing new agrochemicals and intermediates. The proposal envisages to synergize the knowledge and competence available with various CSIR labs for delivery of new agrochemicals and intermediates.

Research focus

To develop:

- New Agrochemical Molecules and Processes
- Market driven technologies for Agrochemicals and Intermediates
- Newer fungicides and insecticides with new mode of action
- Biopesticides and Water Soluble Formulations

Envisaged outcomes/outputs

- Technologies for agrochemicals/ intermediates
- New bio-actives from plant origin
- Value added products from agro-waste
- New Chemical Entities based on natural product leads

3.2.4.6 NCL-IGIB center (NCL, Pune)

The attempt to create NCL-IGIB center is a unique endeavor where scientists from different disciplines come together and exchange knowledge and expertise while working towards achieving common scientific goals. Biology and chemistry are two complementary areas of science where the insight gained from one is useful in the context of the other. In this joint venture, the principal goal is amalgamation of knowledge and expertise in biology and chemistry, the core expertise areas of the two Institutes, for better understanding of contemporary research problems.

Research focus

- To create a pool of young chemists and biologists who can work at the interface of biology and chemistry and to engage in exciting programmes of interdisciplinary research.
- To provide opportunity to scientists of both NCL and IGIB to share knowledge as well as facilities and best practices of both the institutions.
- For enhancing interaction to create a new breed of scientists, with experience and training in both chemistry and biology addressing the New Biology research in the post-genome sequencing era to provide for tomorrow's human resource requirements.

Envisaged outcomes/outputs

Following areas of high science and research are identified for generation of new knowledge:

- Chemchips for Protease Inhibitors and Aptamers for Diagnostic Development
- Nanomaterials in biology: structure-function studies
- Novo Designed Bioactive Peptidomimetic Scaffolds for Disrupting Protein-Protein Interactions
- Re-engineering discontinued drug molecules for use in novel applications and understanding drug toxicity by Proteomic Approache

3.2.4.7 Polymer supported immobilized enzymes for chiral combinatorial biocatalysis and chiral resolution of racemic drug molecules (*NCL,* RRL-Jammu*)*

Enzymes are frequently used in biocatalytic reactions because they couple a wide specificity to high *regio* and *enantio* selectivity. Immobilization of enzymes has attained great interest due to easy separation of the immobilized enzymes from reaction mixture thus allowing the development of continuous processes, enabling greater control of the catalytic process and therefore permitting economically utilization of an otherwise cost - prohibitive enzyme. The present project envisages developments of methods for obtaining a library of organic molecule derivatives using enzymes such as acyltransferases, glycosyl transferases, aminotransferases and alcohol dehydrogenases, proteases and lipases on porous functionalised polymers of required hydrophilicity and hydrophobicity.

Research focus

- To synthesize porous polymers by HIPE, FP and other methodologies in beaded and monolithic forms.
- To immobilize enzymes and application of immobilized enzymes for the racemic drug/ drug intermediates such as b-lactams, propranolol. (taxol side chain, B blocker drug intermediates).
- To develop bench level process for immobilized enzymes.
- To use immobilized enzymes for kinetic resolution of racemic drug/ drug intermediate at bench scale process.
- To scale up and simplify down stream processing for product isolation for the development of simple enzymatic processes.
- To develop methodologies for high throughput screening/analysis.
- To carryout reactions of immobilized enzymes with natural products obtained from marine environment to produce a library of products.
- To screening of the products for biological activities.

Envisaged outcomes/outputs

- Discovery of new biologically active molecules which may directly be useful as drugs or pesticides, or may provide leads.
- Methods for high throughput screening for different kinds of enzymatic reactions.
- Polymer for immobilizing higher concentration of energy.
- Human resource in this new emerging area of science.

3.2.4.8 Conducting polymer paints and coatings for corrosion protection and shielding of concrete structures in strategic areas (*NCL,* NPL, CECRI)

Electronically conducting polymers are a new class of materials with interesting potential applications in number of technologies like an electrode material in primary and secondary batteries, shielding of electronic equipments from electromagnetic pollution, radar absorbing materials etc. They also have the redox properties which are useful in corrosion inhibition coatings. Protection of steel reinforcement against long term corrosion in building and other concrete structures is vital. Another area for the application of these materials is in radar absorption in protecting structures used by defence in strategic locations (bunkers, radar monitoring, transmission towers etc.) against military attack. The proposal is made to use conducting polymers such as polyaniline, polythiophene or their derivatives to achieve the desired products.

Research focus

- To study the application of conducting paints on concrete structures & conductive cement composites in protective structure fabrication.
- To develop corrosion preventive conducting polymers coatings for iron & mild steel used in the concrete structures
- To study the microwave response of conducting paint and conductive cement composites in 8-12 GHz range.

Envisaged outcomes/outputs

- Technical know how for new large scale application of conducting polymers in protection of construction, buildings and structures in strategic areas
- Strategic materials and trained manpower for handling the same

NATIONAL FACILITY

3.2.4.9 Center of excellence for Lipid Research (IICT)

The requirement of the country for edible oil is continually increasing. This has put tremendous pressure on indigenous known resources of oil. Quality oil for all has become a primary requirement. IICT has been working in the area of oils for long and has developed sound knowledgebase and pool of human resources. The cration of facility at IICT aims at establishing a dedicated "Centre of Excellence for Lipid Research" with all the processing and the quality control facilities for the benefit of Indian vegetable oil industry.

Research focus

The facility aims at establishing a dedicated "Centre of Excellence for Lipid Research" with all the processing and the quality control facilities for the benefit of Indian vegetable oil industry. The centre will focus nine thrust areas while creating five specialized analytical testing laboratories. The thurst areas are:

- Screening of Newer / Lesser known Oil Seeds in India for Commercial Exploitation as Edible and Industrial Applications
- Newer Methods for Oilseed and Vegetable oil processing
- Development of Separation Processes for the Isolation of Value-added Products from Vegetable Oils and Allied Products
- Vegetable Oil-based Novel Organic Intermediates as Substitutes for Petrochemicals and Specialty Chemicals
- Development of Eco-friendly Process for Biodiesel from Multi-feedstock and Value-addition to its By-products
- Biotransformations of Lipids
- Nutritional Biochemistry of Lipids
- Lipoconjugated Drugs
- Development of Simple Adulteration Techniques for Vegetable Oils

Envisaged outcomes/outputs

- The focused thrust areas of the Centre to strengthen the country's vegetable oil industry, which is the second largest sector after petrochemicals.
- Five dedicated testing facilities to cater the needs of Indian vegetable oil industry
- Trained personnel for Indian Vegetable oil Industry.

Total Plan budgetary requirement projected for the Sector is Rs. 263 crore

3.2.5 EARTH SYSTEM SCIENCE

Only mother earth inhabits living beings known to exist in this universe. To help the fortuitous humans evolve this planet appears to have undergone turbulent times ever since it formed. A change from its initial fireball status to formation of well-segregated crust, oceans and atmosphere reservoirs has been critical for the origin of life about $3.5.x10^9$ years ago. The life survived multitude of natural onslaughts through violent volcanic eruptions, bolide impacts, earthquakes and ice ages. The life withstood these catastrophic events to evolve further into developed life forms including human beings. However, the most recent danger to the future existence of life on this planet is through human activities that are interfering with the natural phenomena. While this interference by the modern man is like 'slow poisoning', natural calamities such as earthquakes, some times followed by tsunamis, and storms/cyclones cause mass mortality. Although human interference with climate is thought to be slow, several natural processes such as melting of ice-sheets in Polar Regions and increasing occurrences of atmospheric disturbances have been on the rise and linked to 'Global Change'.

The increased awareness of the natural and anthropogenic processes that threaten the future of the life paves the way for emergence of 'Earth System Science' that attempts to understand processes within these reservoirs and interactions among them. "Earth system science" views the Earth as a synergistic physical system of interrelated phenomena, governed by complex processes involving the geosphere, atmosphere, hydrosphere and biosphere. There is need to emphasize relevant interactions of chemical, physical, biological and dynamical processes that extend over spatial scales from microns to the size of planetary orbits, and over time scales of milliseconds to billions of years. It constitutes a complex multidisciplinary intermesh of branches of knowledge dealing with natural phenomena as well as anthropogenic forces operating in the earth's realm. Natural disasters and hazards evoke awe and fear amongst the poor and the rich, the learned and the not so learned, and perhaps most life forms that dwell on this planet.

CSIR has been playing a major role in understanding the processes that shape the land, oceans and atmosphere. CSIR laboratories are also engaged in survey of our land and offshore regions for minerals as well as bio-resources. It has made remarkable contributions to the areas of Earth structure, mapping of hazard zones and hazard mitigation, exploration of mineral and water resources, mining, extraction and beneficiation of various minerals, ocean dynamics and its biogeochemistry and is at present paying considerable attention to the exploration of gas hydrates and hydrocarbons to help meet the energy demands of the country.

The approach of the sector during Eleventh Five Year Plan, to register its S&T thrust in the sector, would be to work under Supra Institutional Projects, Network Projects and Inter Agency Projects. The Sectoral Group has formulated 4 **Supra Institutional Projects** viz. **(i)** Evolution of the Indian Lithosphere, **(ii)** Science for development of a forecasting system for the waters around India, **(iii)** Multi-scale simulation and quantification of sustainability and vulnerability under climate variability and climate stress and other natural hazards, and **(iv)** Seismic hazard-risk evaluation.

The **Network projects** includes **(i)** On-land and Off-shore Integrated Geophysical Studies to map the Lithospheric Structure along Kavali-Udipi Profile**; (ii)** Atmosphere carbon dioxide sequestration through fertilization of a high-nutrients-low chlorophyll (HNLC) oceanic region with iron; **(iii)** Tectonic and oceanic processes along the Indian Ridge system and back arc basins, **(iv)** Multi-scale Modelling Platform, **(v)** Trace Gases, Aerosols, radiation and Impact Assessment, **(vi)** Artificial recharge studies in Hard rock areas in Basaltic environment in Maharashtra and Madhya Pradesh, **(vii)** Basic resource management using genomic tools in contaminated soil

The **inter-agency projects** of the sector include

(i) Integrated Geophysical Studies along Daman–Jabalpur Profile in Central India, **(ii)** Dynamics of separation of key Gondwanaland blocks: An integrated petrotectonic approach to decipher the early evolution of the western Indian Ocean (WIOPET), **(iii)** Development of a High-Resolution Analysis for gridded data set of meteorological and environmental data for Indian region, and **(iv)** Near-real time prediction of ionospheric and tropospheric corrections in radio signals.

A new facility "Indian SHRIMP (Sensitive High Resolution Ion Micro Probe) is also proposed to be created.

SUPRA-INSTITUTIONAL PROJECTS

3.2.5.1 Evolution of the Indian lithosphere-focus on major earth processes, natural resources and the geo-environment since the break-up of gondwana super continent (NGRI)

With an ever growing appreciation of space–time relationships between the endogenic and exogenic processes of the Earth, current earth science research, world wide is focused on improving the fine-scale linkages between the different 'Systems' of the Earth System Science (ESS). This is aptly reflected in the 2005 strategic vision of the UNESCO-IUGS-IGP (the International GeoScience Program). 'Volcanism', especially basaltic volcanism, the central theme of this project, is a fundamental process that underpins the thermal and chemical evolution of not only the Earth but all terrestrial planets. Basaltic magmas are extracted by the direct partial melting of Earth's convective mantle causing profound changes to the composition and rheology of their lithospheric source regions. Thus, they comprise a probe into the compositional and physical conditions of the deep-mantle regions that are inaccessible to direct observation. Rapid eruption and accumulation of voluminous volcanic products at the continental surface, e.g., in the "flood basalt provinces" or the "continental Large Igneous Provinces" (LIPs) affect regional and global ecological systems to the extant that 'mass extinctions' of flora and fauna, at the different periods in the earth's history, are linked directly to such volcanic episodes.

The project envisages detailed studies on the Deccan Volcanic Province (DVP) of Western and central India (intra plate) and tectonism and volcanism along the Burmese-Andaman arc region of the Northeastern and Eastern India (a convergent plate margin). It would address range of fundamental problems and unresolved questions pertinent to the Large Igneous Provinces and active subduction zones with far reaching implications to aspects of environment, earth resources and hazard evaluation through innovative approaches that are possible because of the application of state-of-art technologies and methodologies.

Research focus

- The project aims to contribute significantly to the basic understanding of major earth processes such as Plate Tectonics and Plume Tectonics and their influence on aspects of the geo-environment both past and present. The project would also focus R&D efforts in the area of mineral exploration, especially in terms of hydrocarbons, base metals and Platinum Group Elements (PGE) apart from diamond bearing kimberlites.

Envisaged outcomes/outputs:

- The proposed integrated studies would offer a clear evaluation of the competing models for the generation of Deccan Volcanic Province: Plume vs Non Plume hypothesis; Assessment of space-time linkages volcanism and evolution of life forms; Genetic linkages of possible plume sources?; Offer constraints on the correlation of major orogenic structures like the Central Indian tectonic across the Indian shield with other Gondwanic fragments.; Lithosopheric structure in terms of its velocity, composition, rheology in regions overlain by the Deccan; Delineation of subtrappean Mesozoic sediments in the central and eastern parts of the Deccan Volcanic Province for their Hydrocarbon potential; Subduction geometry, seismogenesis, kinematics along the active Indian plate margins; Himalaya, Burmese-Andaman arc regions etc.; Improved methodologies for assessment and management of water resources in the Deccan Volcanic Province; Real time monitoring for the identification of seismically active regions in the continental interior for the better understanding of seismogenesis of intraplate earthquakes vis-à-vis inter plate earthquakes; Microzonation maps for selected large cities; A detailed assessment of Mineralization of PG and gold in Deccan Volcanic Province; Deep crust and upper mantle structure of Saharsa to Sarguda in the Ganga Valley and extensions of Kelsi-Loni profile into the core of the Bastar craton; Improved techniques for Kimberlite/Diamond exploration

3.2.5.2 Science for development of a forecasting system for the waters around India (NIO*)*

Keeping in view the goal to face a worthwhile scientific challenge while being relevant to needs of the society, and to be quantitative, it becomes important to develop science for forecasting all major oceanic variables for the waters around India. The oceanic variables include all the four traditional branches of oceanography, i.e. biological, chemical, geological and physical oceanography. It seems essential to take up the challenge since other agencies such as Indian National Centre for Oceanic Information Systems (INCOIS) of the Ministry of Earth Sciences, have plans to make predictions of marine conditions in the waters around India to serve the large community (involved in shipping, fishing, offshore activities for gas and oil exploration, etc.) that uses these waters.

In order to develop a forecasting system for coastal waters of India, it is essential to understand the science that drives the variability of forecastable parameters. To generate the required knowledge both bench top experiments in the laboratory and realtime measurements along the coast would be necessary.

For the field measurements, the major focus is to cover coastal areas with diverse regimes that help develop forecasting expertise needed for varied ecosystems along the Indian coastline.

Research focus

The project envisages to address issues such as:

- Observation and modelling the interaction between Indian Ocean, atmosphere and coastal seas (OMICS)
- Observations of sea level and surface meteorological data from coastal locations
- Impact on the coastal zone due to natural and anthropogenic pressures
- Biogeochemical and ecosystem responses to global climate change and anthropogenic perturbations, and transfers across interfaces in the North Indian Ocean
- Understanding coastal upwelling: a system biology approach to delineate Web-dynamics from primary to tertiary levels
- Eco-biogeography of the estuarine and coastal waters of the Southwest coast of India; physical and biogeochemical dynamics of estuarine and coastal ecosystems along the east coast of India
- Indian climate and phytoplankton variability; marine environmental studies for sustainable developments in the coastal zone of India
- Marine pollution assessment and ecotoxicology
- Autonomous vehicles and instrumentation for oceanography
- Swath Bathymetric, geologic and related hydrographic investigations of the Exclusive Economic Zone (EEZ)
- Role of the equatorial Indian Ocean processes on the Climate Variability (EIO-CLIVAR)
- Engineering analysis of coastal processes for marine structures and technology development towards marine activities
- Paleoceanography of the northern Indian Ocean – an interdisciplinary approach
- Structure, tectonics and morphology of ECMI and Bengal Fan
- Application of geological and geophysical methods in marine archaeology and underwater explorations.

Envisaged outcomes/outputs

- Setting up of observational network in coastal waters of India including long-term ocean time-series measurements stations on either side of India
- Quantification of water flows and development of ocean modeling system
- Comprehensive understanding of biogeochemical processes for their quantification to develop budget and process models
- Develop predictive models for tertiary production and fishery forecasting in upwelling zone of Southwest coast of India
- Variability's in environemental properties in estuarine and coastal waters of the western Bay of Bengal, covering possibly the extreme events
- Response of phytoplankton to climatic events; high resolution bathymetric measurements
- Study of past changes in Indian monsoon and sea-level variations.

3.2.5.3 Multi-scale simulation and quantification of sustainability and vulnerability under climate variability and climate stress and other natural hazards (CMMACS)

Climate variability and climate change introduce a number of stresses in terms of water availability, viability of traditional agricultural practice (crop type, sowing schedule etc.) and others. As nature and magnitudes of climate variability and climate change as well as parameters like land use are highly regional, the impacts of climate variability and climate change are also likely to be highly regional. This requires reliable, multiple scenario forecasts for climate variability and climate change to assess vulnerability to climate stress.

However, usefulness of such forecasts depends strongly on quality, range and scope of these forecasts. Only a comprehensive approach combining, model design and calibration, adequate database, forecast methodology and diagnostics as well as value addition can generate inputs with desirable scope and reliability for addressing issues like climate variability and climate change. This primary odeling platform needs to be complimented by models of sustainability and vulnerability involving parameters like crop – specific water stresses indices under different climate change scenarios obtained from the primary modeling platform.

A contentious issue in recent years has been about whether the average carbon emission (and CO_2) to the atmosphere has been increasing, and of determining and quantifying the sources and sinks. It becomes necessary to develop reliable model of global carbon cycle and also to open more stations for measurements of Carbon dioxide (CO_2). It is very important to estimate the carbon fluxes in India reliably and which will be important from the viewpoint of treaty negotiations involving sources and sinks of CO_2 in Asia.

Research focus

To develop a consolidated Hierarchical Modelling Platform with capabilities such as:

- Multi-scale simulation with AGCM for Monsoon
- Tropical Cyclone Simulation
- Meso-scale Simulation with Limited Area Model
- Coupled Ocean – Atmosphere Model
- Hydrological Model; Estimation of Carbon Flux
- Mitigation of Earthquake Hazards.

Envisaged outcomes/outputs

- Multiple-scenario assessment of sustainability for different processes like agriculture and power generation
- Multiple management scenarios for water requirement for sustainable growth at different time scales
- Quantification of hazard assessment due to high impact weather events and other earth system processes
- Capability to model the ocean circulation and thermodynamics would contribute to several programmes such as weather, climate, biological productivity and quantifying sources and sinks of CO_2.

- Carbon flux studies for a better understanding of oceanic uptake of anthropogenic carbon dioxide, and its impact on climate change.

3.2.5.4 Seismic hazard-risk evaluation (RRL-Jorhat)

Ground motion attenuation (with distance) is an essential input parameter in hazard and risk assessments. Broadband seismic instrumentation in the seismic zone is recording numerous small and moderate regional earthquakes. These data, in conjunction with data from a planned active explosion experiment, can be used to produce detailed seismic velocity and attenuation models for the region. These models can then be used, under different source parameter assumptions, to investigate and produce attenuation/distance relations for the study area. Simultaneously estimation of peak ground acceleration would ensure a visual picture of the seismic intensity, seismic motion of an area in micro level for an expected scenario earthquake in that area.

Research focus

- It is envisaged to develop Integrated Seismographic Network of both sensitive and strong motion instrumentation for on-line earthquake monitoring and precursor studies; Constant geodetic monitoring of crustal blocks to measure relative plate movements; Preparation of practical micro-zoning procedures & improvement of modeling strong ground motion by inclusion of recent field observation data; to develop a suitable algorithm and prototype strategy plan for hazard reduction and application of scientific knowledge, proven engineering and educational techniques toward disaster mitigation.

Envisaged outcomes/outputs

- Generation of broadband seismic data from crustal earthquakes /large controlled explosions in the study area.
- Report on velocity structure and attenuation estimates for the same area;
- A detailed waveform modeling of path effects and wave excitation effects on seismic data collected from recent earthquakes/explosion within the study area and surrounding region;
- Simulation of seismic wave propagation to derive rupture model and estimated peak ground acceleration;
- A quantitative assessment of seismic motion related to geomorphological, subsurface features and geological including damage analysis at large scale level.

NETWORK PROJECTS

3.2.5.5 On-land and Off-shore integrated geophysical studies to map the lithospheric structure along kavali-udipi profile (*NGRI* ,NIO)

Experimental geophysical surveys in various parts of the country by NGRI using seismic & gravity and also other methods in collaboration with OIDB / ONGC over the last few years have been successful in mapping sediments, basement and Moho configuration underlying the surface of the earth. Apart from delineation of sediments, mapping of the deep crustal structure, detection of buried faults, fractures in the basement helps in many ways of understanding for the evolution of the eastern and western Dharwar craton.

To study the crustal evolution and associated tectonics of such complex regions, it is essential to know the detailed structure of the deeper parts of the earth’s crust which often have strong bearing on the occurrence of minerals and hydrocarbons. To delineate underlying tectonic structural pattern, several types of geophysical and geological methods have been used throughout the world.

Research focus

- Study of Deep electrical and seismic structure of the continental margins across the Eastern and Western off-shore along a profile extending the Kavali-Udipi transect. Estimate the thickness of the sediments in critical off-shore basins such as KG-basin.

Envisaged outputs/outcomes

- Deep electrical and seismic structure of the continental margins across the Eastern and Western off-shore along a profile extending the Kavali-Udipi transect; Estimate the thickness of the sediments in critical off-shore basins such as KG-basin.

3.2.5.6 Atmosphere carbon dioxide sequestration through fertilization of a high-nutrients-low chlorophyll (HNLC) oceanic region with iron. (*NIO* CCMB, CMMACS & NEERI)

Human activities are continuously altering the Earth's natural environment particularly since the industrialization began in the mid-nineteenth century. The most important impact has been in the form of enhanced emissions of the heat trapping (greenhouse) gases, mainly carbon dioxide (CO_2), to the atmosphere. These emissions have the potential to significantly modify atmospheric composition as well as the radiation balance of our planet leading to global warming and stratospheric ozone depletion. These anthropogenic perturbations of the natural system are expected to bring about significant shifts in the climate all over the world.

In order to evaluate the effect of the anthropogenic perturbations on climate it is important to recognize the magnitude of changes that are forced by natural processes. It has long been known that the earth has experienced regular climatic cycles of about 100,000 years duration that comprised of cold glacial periods (ice ages) and warm interglacials. The atmospheric chemical composition varied a great deal associated with these climatic oscillations. For example, during the last glacial maximum, about 21,000 years ago, the atmospheric CO_2 content was about 190 ppmv (parts per million by volume), about 90 ppmv lower than the pre-industrial value. Since industrialization the atmospheric CO_2 level has increased from 280 ppmv to over 380 ppmv today. The latter increase has been mainly due to the burning of fossil fuels and deforestation. However, while the natural changes in atmospheric CO_2 associated with the climatic cycles occurred over a few thousand years, a comparable change has been effected due to human activities in just two centuries. It is almost certain that the global climate will be significantly altered, if it has not been happening already, by the continuous build-up of CO_2 and also of other greenhouse gases such as CH_4 and N_2O in the atmosphere. A doubling of current atmospheric CO_2 content, for example, is estimated to lead to an increase in the average atmospheric temperature by 2 to 4.5ºC by the end of this century.

Biological Pump exerts the *principal* control on atmospheric CO_2 content, and it is generally accepted that the glacial-interglacial cyclic changes in the CO_2 content, as revealed by the ice core records, were caused by cyclic changes in the efficiency of the biological pump. The most probable way by which this could have happened is as follows.

Primary production in the ocean is limited by the availability of both macronutrients (generally combined forms of nitrogen, phosphorus and silicon) and micronutrients (trace elements mainly iron). While in most areas the macronutrient concentrations in the surface waters are kept at very low levels due to uptake by phytoplankton, such that primary production is often limited by one of these macronutrients (generally nitrogen), there are areas such as the equatorial Pacific, Northeast Pacific and the Southern Ocean where the macronutrient concentrations are quite high (e.g. nitrate > 20 micromolar), and yet the primary production and standing stocks of chlorophyll are quite low. It has been proposed that these remote areas receive little supply of iron from continental sources because of which this element becomes bio-limiting. Over the past decade, evidence has been piling in support of this hypothesis. This includes results of experiments of iron fertilization carried out in almost all known high-nutrients, low clorophyll (HNLC) regions of the world oceans. These experiments have demonstrated increases in the chlorophyll biomass and decrease in partial pressure of carbon dioxide (pCO_2) in the patches that were fertilized with iron with reference to the region outside the zone of fertilization.

All eight pilot scale iron fertilization experiments carried out so far were conducted by scientists of the developed countries, and with the exception of Japan. No Asian country has demonstrated the capabilities to carry out such experiments. Moreover, none of these experiments was conducted in the Antarctic peninsular region, an area that used to support large krill biomass which has sharply declined recently.

Research focus

The project aims to**:**

- develop expertise in India for induced CO_2 sequestration by the ocean
- study the effect of enhanced carbon production on surface carbon chemistry, food web-structure, and particulate export to the deep sea
- determine the fate of carbon exported from the oceanic surface layer
- investigate the adverse effects, if any, of enhanced carbon production on ecosystem (e.g. obnoxious blooms) and biogeochemical cycling (e.g. production of greenhouse gases)
- assess the socio-economic impact and techno-commercial viability of iron fertilization as a possible mechanism of mitigation of greenhouse warming.

Envisaged outcomes/outputs

- Generation of new knowledge on ocean biogeochemistry and ecosystem functioning; Disseminated through publications in high impact journals (~20 papers) as well as to public through electronic and print media; Acquisition of technology for ocean fertilization that may have commercial applications in future.

3.2.5.7 Tectonic and oceanic processes along the Indian Ridge system and back arc basins. (*NIO* , NGRI)

Understanding the causal links among magmatic, tectonic, hydrothermal and biological processes at mid-ocean ridge [MOR] and backarc spreading centers is of global importance and the Ridge community world-over is actively engaged in this research. New Millennium Ocean floor observatory over the Juan de Fuca Ridge, NE Pacific and the decadal plan to monitor the Mid-Atlantic Ridge (MoMAR) are two such important global programs.

Research focus

The project envisages :

- Characterization of mid-ocean ridges and Andaman backarc spreading center in terms of tectonic, volcanic, and hydrothermal processes; Decipher emplacement tectonics of ultramafic rocks at the ridge-transform intersections and their genesis
- Delineation of zones of hydrothermal mineralisation and location of polymetallic massive sulphides
- Influence of hydrothermal processes on the seafloor and sub-seafloor ecosystems using physical, chemical and biological parameters
- To understand the deep; crustal structure and tectonics of the Andaman subduction zone encompassing trench-arc-back-arc system.

Envisaged outcomes/outputs

- Location of active hydrothermal vent fields in the Northern Indian Ocean; Delineation of zones of hydrothermal mineralization and mapping of the occurrence of polymetallic massive sulphide deposits associated with hydrothermal vents;Harnessing of microbes and thermostable enzymes that occur at the high temperature hydrothermal vent systems for marine biotechnological applications; Generation of knowledge base about the influence of ridge processes on the mineralisation, tectonics, magmatism and deep sea ecosystems, and about the regional structure and tectonics of the Andaman Sea; Creation of National deep submergence ROV facility.

3.2.5.8 Multi-scale modelling platform (*CMMACS,* NPL, CIMAP,RRL-Bhub.)

The current approach in environmental modelling and simulation is by and large compartmental contrary to the reality wherein different components of the environment are linked to each other and part of one environmental system (biosphere). Decisions based on compartmental approach are bound to be inaccurate and some times even erroneous thus leading to environmental damage. Reliable and quantified estimates and forecasts of various environmental processes and parameters can significantly aid cost-effective planning and implementation of a number of industrial processes

Research focus

- The project envisages to develop, validation and value addition of Multi-scale Modelling Platform.

Envisaged outcomes/outputs

- A multi-scale modelling platform which offers generic modelling and forecasting capability through process specific and location specific models, along with a comprehensive database.

3.2.5.9 Trace gases, aerosols, radiation and impact assessment *(NPL* , RRL-BH, IICT, IIP, NIO, CFRI, CMRI, CGCRI, CRRI, CECRI, NCL, C-MMACS)

Improving the currently known country level estimates of aerosols, radiatively active gases and assessing/predicting their impact on human health and agriculture with the progress of Global Change is a dire necessity for preparing the country and its policy makers in order to adopt mitigation options and also counteract international priorities/trends in the regional interest.

Research focus

- To create inputs for prediction of changes in atmospheric composition, budgets and assessing their impact on radiation forcing, agriculture and human health through networked monitoring and modeling efforts.
- To create additional monitoring systems needed to meet the requirements of atmospheric composition data for NATCOM, ABC, MAIRS and similar nationally coordinated programmes.

Envisaged outcomes/outputs

- Improving the currently known country level estimates of aerosols, radiatively active gases and assessing/predicting their impact on human health and agriculture. It will help policy makers to adopt mitigation options and also counteract international priorities/trends in the regional interest.

3.2.5.10 Uncertainty reduction, vulnerabilityl impact assessment, mitigation, policy intervention and capacity building for global change *(NPL, RRL-Bhub., RRL-Bhopal, CRRI, IIP, CFRI, CMRI, NCL, NEERI & CLRI)*

The significance of researches to measure, understand, mitigate, predict global change and generate impact scenarios cannot be overemphasized. A host of international programmes therefore are offering opportunities to partake in global level impact observation and assessment/scenario prediction programmes, In India, MOEF and DST are major funding agencies encouraging such researches. ICAR, ICMR andISRO have all mounted large internal programmes to specifically address issues pertinent to them. CSIR scientists are also deriving benefits from these.

CSIR's expertise in relevant areas is extensive and covers diverse disciplnes. It can address scientific issues relavant to atmosphere, hydrosphere, geosphere, and biosphere through observations as well as process to meso-scale modeling, including scenario generation in some cases. Clean and energy efficient technologies related to energy, mines, transport, etc. that deserve examination as mitigation options are being carried out in its labs. There have been also a few technology development efforts to help in vulnerability assessments. The scientific data bases to help in policy decision support by government agencies have been generated by CSIR labs.

Research focus

Global change related research and development efforts would have the following broad objectives:

- Uncertainty reduction in national GHG emission inventories
- Observation and modeling of change to understand variability in the ambient
- Impact assessment primarily on food production, potable water availability and human health
- Technologies/options for mitigation and their relative evaluation
- Scientific data support for policy decisions
- Internal and external capacity building

Envisaged Outputs/Outcomes

- More reliable GHG estimates in Indian context
- Zoning and mapping based on vulnerability and impact assessment due to Global change
- Technology development and mitigation options
- Scientific base for Policy development
- Capacity building

INTER-AGENCY PROJECTS

3.2.5.11 Integrated geophysical studies along daman-Jabalpur profile in central India (NGRI, DGH, MNES, DST, NPC, IIT-Bombay)

Research focus

- Delineation of sub-crustal geometry of the deep faults and major tectonic boundaries and map the configuration of sedimentary basins both underlying the Deccan lava flows and included in the basement complexes.
- Characterization of anomalous zones related to geothermal resource.
- Development of methodologies for interpretation of multiparametric datasets with special reference to crustal structure-rheology and geothermal fields.

Envisaged outcomes/outputs

- Detailed electrical conductivity, gravity and seismic imaging of the deep crust along the Daman-Jabalpur profile.
- Heat flow and thermal conductivity data along specific zones favorable for potential geothermal energy.
- Information dissemination and training opportunities in modern geophysical methodologies through Seminars and Wrokshops.

3.2.5.12 Dynamics of separation of key Gondwana land blocks: An integrated petrotectonic approach to decipher the early evolution of the western Indian Ocean (WIOPET). (*NIO,* IITs, Universities, ONGC)

The origin and evolution of the Indian Ocean is the most complicated of the three major oceans in the world. Its formation is a consequence of the breakup, about 150 Ma, of the southern super continent Gondwanaland. More than 5000 km movement of the Indian subcontinent to the northeast temporarily halted as India collided with Eurasia at about 50 Ma. The Western Indian Ocean (WIO) holds signatures of such enormous crustal transshipment. The separation of the crusts in the past and formation of their margins have continued to be an absorbing aspect, albeit with controversies.

In addition, the WIO is the home of at least two major hotspots - Marion and Reunion. The significance of hotspot in the framework of global tectonics and continental drift is well known. Naturally, the concept and evolution of hotspot volcanism and plume dynamics have been priority items of the academicians. Hence, there is a need to examine these concepts in the light of newer data set.

The western Indian Ocean also holds several prominent yet anomalous tectono-magmatic features. For example, the Amirante Trench / Ridge, located northwest end of the curvilinear Mascarene Plateau (north of Madagascar), is an enigma. The origin of this anomalous feature is yet to be sorted out emphatically. Again, the Mascarene Plateau shows a fundamental change in geological characters at some point along its length with the northern portion unequivocally of continental origin (age 650 Ma) and the southern having oceanic affinity (age 0 Ma).

Accordingly, in a bid to address several outstanding issues, extensive field and laboratory campaign in the western Indian Ocean is conceived and scheduled under the proposed WIOPET network program to acquire petrological and geodynamic data. An integration of such petrotectonic dataset, we believe, should help understand the dynamics of separation of key Gondwanaland blocks and decipher the early evolution of the western Indian Ocean.

Research focus

The Project proposes for:

- Petrotectonic investigations of the onshore and offshore segments of the Continental Margins, including Plateaus, Highs, Rifts, Seamounts, and Dyke-swarms;
- Petrotectonic investigation of some anomalous features in the WIO; to Examine timing, source and related aspects of volcanism in the WIO;
- To Integrate petrology and geodynamic results to develop well-constrained models for early (100-50 Ma) evolution of the Western Indian Ocean

Envisaged outcomes/outputs

- A well-constrained Petrotectonic model of WIO evolution; Creating GIS compatible database of basic petrology and geodynamics; Publications in high IF journals: Upto ten papers each of ≥ 1.5 Impact Factor; Three-Dimensional animations of the development of the western Indian Ocean

3.2.5.13 Development of a high-resolution analysis (*CMMACS* NPL, IAF, Govt of Karnataka, Tezpur University, Andhra University)

The Indian region is characterized by a wide variety of terrain; the north-south extent of India stretches from near-equator to beyond mid-latitudes. The structure of the coastline is ragged, implying sharp land-ocean transitions. These features require meteorological and environmental data with fine horizontal resolution, preferably at scales 10 km or less. There is, however, no such gridded analysis at such resolution available at present.

Research focus

The project envisages:

- develop a gridded data set at a resolution of about 10 kms by combining local observations, satellite data and model simulations;
- validate the gridded data set (Analysis) through comparison with high resolution observations wherever available;
- apply and evaluate the gridded data set (Analysis) for model initial and boundary conditions and for forecast verification.

Envisaged outcomes/outputs

- Under Public Goods: Quality data with high spatio-temporal resolution over select locations with high vulnerability for timely warning and alerts which could significantly prevent loss of life and property. Under Private Goods: Prototype for such weather informatics over selected locations for efficient and smooth running of many industries and ventures, from Airlines to crop planning. Under Strategic Goods: High resolution data over a wide domain with integration of meso-scale models for processes like fog formation and rainfall.

3.2.5.14 Near-real time prediction of ionospheric and tropospheric corrections in radio signals (*NPL* , Aeronautical Development Agency, Solid State Physics Lab. Physical research Laboratory, Universities, Defense, Railways, Police Dept. etc)

NPL has led the growth of radio sciences in the country since IGY for applications to both tropospheric as well as ionospheric communications. Today as a result, NPL is the only laboratory in India that has the expertise in characterizing ionized and non-ionized media in both ionospheric as well as the tropospheric regions of the Earth's atmosphere for studies and applications of propagation of radio signals for communication or for strategic applications such as position fixing, navigation, etc apart from basic scientific research in space physics. NPL through its Regional Warning Centre has been providing space weather alerts and solar activity predictions to few government agencies dependent on radio communication for their day-to-day operations. The importance of improving the capability for predicting ionospheric and tropospheric corrections to account for impairment of communicated radio signals in frequency bands, used currently or planned in near future, by atmospheric media because of various natural processes cannot be over emphasized for both social and strategic applications. NPL is gearing up to take on this complex and challenging task of national importance in the XI plan period. Stake holders in Defense, Aerospace and other sectors would need to be associated in doing this in a most effective manner. Ionosonde network would need to be augmented. Also frequency bands to be explored signal impairment processes would include, UWB Technology linked bands, 60 GHz, Ku-Ka band, 2-6 GHz, naval communication bands using evaporation ducts and VLF-LF bands.

Research focus

➲ The project aims to improve the capability of hear real time prediction of ionospheric/tropospheric corrections in radio signals over the whole country for a variety of societal, scientific as well as strategic applications including communication, position fixing, surveillance, military, missile guidance, geodesy, and also for improved understanding of equatorial ionosphere dynamics, etc.

Envisaged outcomes/outputs

➲ This improved prediction has a variety of societal, scientific as well as strategic applications including communication, position fixing, surveillance, military, missile guidance, geodesy, improved understanding of equatorial ionospheric dynamics, etc and it will be applied to all these by tying up with user agencies. These include NAL, ISRO/SPL, Defense, Space, Railways, Police, etc. SPL, PRL and several Universities will be partners in realizing the network and carrying out research in space physics using the new data sets and improved models.

NATIONAL FACILITY

3.2.5.15 Creation of Indian SHRIMP (Sensitive High Resolution Ion Micro Probe) (NGRI)

The Indian continental crust is predominantly comprised of Precambrian formations (> ca. 500 Ma old). Precambrian formations, in general are the store house of most of our metallic ore deposits: iron, base metals, gold, platinum group elements, titanium, chromium, nickel, uranium, thorium, aluminium and so on. Although the geological maps for the entire sub-continent are now available, a challenging task ahead is to understand the spatial and temporal correlations of the rock formations across such an expansive landmass. Furthermore, it has become increasingly difficult to find new world class mineral deposits as one has to deal invariably with concealed prospects. The mineral industry, the world over looks forward to the Earth Scientists for comprehensive understanding of mineral systems within current and prospective but otherwise concealed terranes.

Just as 'index fossils' are important to Phanerozoic stratigraphy, U-Pb geochronology particularly on a U/Pb – enriched phase like zircon ($ZrSiO_4$) has been responsible for a major leap forward in unraveling complex age relationships of Precambrian terrains. Barring a few determinations carried out in laboratories abroad and a very limited set of results from indigenous laboratories, the vast stretches of Precambrian formations of the Indian shield remain geochronologically unexplored leading to glaring gaps in our basic understanding of the crustal evolution patterns and metallogeny.

Aim of the facility

- The project plans to create a fully-operational SHRIMP (Sensitive High Resolution Ion Micro Probe) national facility together with a team of dedicated scientists with competence in several applications such as U-Pb zircon, Ar-Ar geochronology, Sulphur and Oxygen isotope systematics; Generation of new data bases on the chronology magmatic, metamorphic, sedimentation and deformation events over the Indian shield throughout its protracted evolution; Event stratigraphy and related metallogeny of the Indian shield leading to exploration strategies for concealed mineral resources; New HRD opportunities in several new lines of frontier areas in Earth System Sciences; Provide the framework for a close linkage with mineral industry and R&D institutes and Universities.

Envisaged outcomes/outputs

- Creation of a fully-operational SHRIMP national facility together with a team of dedicated scientists with competence in several applications such as U-Pb zircon, Ar-Ar geochronology, Sulphur and Oxygen isotope systematics.

Total Plan budgetary requirement projected for the Sector is Rs. 687 crore

3.2.6 ECOLOGY & ENVIRONMENT

Indian Government recognizing the severity of environmental problems has adopted a comprehensive policy to address the environment. India was the first country to insert an amendment into its constitution allowing for the state to intervene and to protect public health, forests and wildlife. Further, in response to national commitment to a clean environment (mandated in the Constitution in Articles 48A and 51A (g), strengthened by judicial interpretation of Article 21), the Government has come out with an Environmental policy in 2006. The dominant theme of this policy is that people dependent on particular resources obtain better livelihoods from conservation, than from degradation of the resource.

In accordance with national needs, for the ensuing XI Five Year Plan CSIR endeavours to provide leadership in environmental protection for sustainable development and dedicates itself in the service of mankind by providing innovative and effective solutions to environmental and natural resource problems.

The thrust areas of CSIR areas in the new Plan would be as follows: To conduct R&D studies on select aspects of Ecology and Environment, which are demanding urgent attention like Climate change studies, Management and preservation of the biodiversity; Environmental monitoring studies; Safe Drinking water; Environmental Biotechnology & Toxicology studies; Zero water discharge processes; Treatment of wastewater; Management of Wastes; Environmental systems Design; Modelling & Optimisation, and Environmental Impact and Risk Assessment studies.

SUPRA-INSTITUTIONAL PROGRAMMES

3.2.6.1 Competence building in the molecular environmental science (NEERI)

Molecular Environment Science builds bridges among chemistry, nanotechnology and genomics. It is an emerging interdisciplinary area and is concerned with the molecular-scale physical and chemical aspects of earth materials, anthropogenic materials and organic substances that govern interactions with the hydrosphere and the biosphere.

Research focus

- NEERI would like to have the focus of molecular environment science as a focal theme of R&D and would like to find out technological solutions for various environmental problems.

Envisaged outcomes/outputs

The proposed project would be helpful in developing technological solutions for the environmental problems caused in the following eight areas:

- Atmospheric pollution
- Environmental genomics,
- Wastewater treatment,
- Environment materials,
- Environmental biotechnology (bio-remediation),
- Solid waste management
- Hazardous waste management and
- Ground water contamination.

3.2.6.2 Assessment and management of environmental pollutants (ITRC)

Considerable concern is being expressed regarding the deterioration of ecology and environment due to industrial, agricultural and domestic wastes. These pollutants are heavy metals, pesticides, polycyclic aromatic hydrocarbons etc. The project proposal addresses the deterioration and restoration of aquatic and terrestrial communities receiving industrial and domestic discharges. The recurring episodes of massive loss of biodiversity throughout the country are a major concern due to these pollutants. In view of this, assessment of extent of damage, based on ecological case studies is needed using short term and long-term toxicological evaluations. This will lead to the prevention and restoration of major ecological damages to our environment.

Research focus

- Identification of major sources of pollutants, use of toxicological biomarkers/ecological indicators to evaluate the risks to the health & environment and development of management strategies for the wastes/effluents including bio-remediation of toxic pollutants to meet the twin objectives of resource optimization and sustainable development.

Envisaged outcomes/outputs

- The proposed work is a multidisciplinary approach towards ecosystem restoration. The inputs stipulated will provide a complete mapping of the situation. This will help to take preventive/anticipatory action for rehabilitation and restoration of damaged ecosystem. The study will also be a model approach to assess and abate pollution problem elsewhere in the country. Based on the data generated the project recommendation will be made to the concern department to take appropriate action for prevention of further degradation.

NETWORK PROJECTS

3.2.6.3 Resource conservation through recycle/reuse of wastes with recourse to recovery of value added products (*NEERI,* CECRI, CLRI, CMERI, CMRI, CSMCRI, NML, RRL-Bhub., SAIL, Jaharia Coal Fields)

The stress on India's environmental resources comes mainly from the pressures for meeting the basic human needs of a large and growing population. Poverty and inadequate availability of the means to fulfill the basic human needs has the impact on the health and integrity of our natural resources (land, soil, water, forests, wildlife etc.). Rapid urbanization and industrial development are putting extreme stress on the environment and ecology by contaminating air, water, and land, directly or indirectly. The problems are further aggravated by the rapidly growing information and electronic industry waste i.e. E-waste.

The easier ways to prevent the pollution are reuse and recycle the wastes generated in the industrial processes and recover value added products from it, wherever possible. Reuse and recycling can reduce a range of pollutants from entering the environment. By reducing the need to extract and process new raw materials, recovery of value added products can eliminate great amount of pollution which is produced during material extraction, refining and processing.

Research focus

- Development of viable processes for the (i) reuse & recycle (ii) recovery of value added products from E-waste, Coal & Mining waste, Iron ore refining dust, Fly ash and Solid wastes from Textile, Steel, & Tannery industries and (iii) their demonstration on reasonable scale.

Envisaged outcomes/outputs

- Development of indigenous processes for the recovery of metals from solid wastes especially e-wastes which is otherwise is going to be a big environmental concern.
- Recycle of the solid waste for the production of value added products such as cement, parchment etc.
- Reuse of wastewater from coal and mining sector for irrigation which has positive impact on areas with water scarcity.

- ➲ Viability of production of hydrogen, a clean fuel for future, from lignite wastes

3.2.6.4 Remediation/ eco-restoration and cleanup of contaminated sites (NEERI,CGCRI,CLRI,CMRI,CSMCRI,IIP,ITRC,IMTECH,NBRI, RRL-Jorhat)

Bioremediation is very cost effective clean-up technology, which warrants interdisciplinary R&D efforts in various disciplines such as environmental engineering, earth sciences, chemistry, toxicology, ecology, microbiology and biochemistry.

Out of available options, in-situ bioremediation has several advantages which include: (i) minimized site disturbance (ii) less expensive compared to *ex-situ* bioremediation and (iii) application of programmed attenuation using genomics and gene manipulation tools which optimizes bioremediation and assures attainment of risk based remediation goal.

The future belongs to sustainable technologies which would optimize the full life cycle of products including environmental, social and economic issues. However there would remain great advantage in adopting *in-situ* bioremediation technology for cleaning contaminated sub-surface water & soil.

Research focus

- ➲ The objective of the networking proposal is to carry out remediation of contaminated sites using the principles of bioremediation including phytoremediation and rhizoremediation and genetic engineering and genomic tools to understand and improve the processes.

Envisaged outcomes/outputs

- ➲ Delineation of microbial & plant species for bioremediation
- ➲ Detection and expression of catabolic genes present in various contaminated sites for clients' and stakeholders' satisfaction.
- ➲ Development of microarray and chips to track acclimated microorganisms capable for bioremediation vis-à-vis quantification og gene pools.
- ➲ Overall outcome will be application of the successfully developed remediation technologies for detoxifying xenobiotics / metals contaminated water/ soil in real life situation.

3.2.6.5 Waste treatment and disposal (*NEERI,* CECRI, CLRI, CSMCRI, IICT,IIP, IMTECH, ITRC, RRL-Bhopal, RRL-Bhub, RRL-Tvm.,)

The industrial and community activities bring short term and long term physical, chemical and biological changes in the environment. The real benefits of developmental activities can result only if the risks of environment degradation are minimised. This can be accomplished through implementation of adequate preventive and control measures.

Every community produces liquid and solid wastes in addition to gaseous emissions from various industrial and anthropogenic activities. The main research theme of this project is to address waste treatment and disposal with recourse to reuse, recycle and value addition.

Research focus

- ➲ The objective of this project is to develop improvised and novel remediation processes and technologies for different wastes including liquid, gaseous and solid with recourse to reuse, recycle and value addition.

Envisaged outcomes/outputs

- Development of feasible technological options for reduction of suspended solids, Biochemical Oxygen Demand, Chemical Oxygen Demand, Nitrogenous compound and Colour.
- Recovery of water from wastewater and to achieve zero liquid discharge concepts, reuse of water from wastewater for industrial and other applications to minimize the natural resource depletion.
- Development of process know how for sewage treatment and nutrient removal using algae
- Optimal utilization of RO rejects after wet oxidation process for its conversion into low molecular weight compounds for enhanced biogas production with increased methane content
- Development of cost-economic microbiological treatment system for pulp & paper mills
- Development of appropriate control strategy/technology for quantification of evaporative and exhaust emissions at Fuel Stations
- Development of emission Control Strategies for Bee Hive Coke Oven
- Development of process for accelerating conversion of compostables of Municipal Solid Waste (MSW) by a microbial (fungal) consortium
- Development of process for accelerating conversion of compostables of MSW by co-composting trials including amendment of MSW with cattle dung, poultry manure etc

3.2.6.6 Climate change and adaptation of species complexes (*IHBT* CSMCRI, NBRI, and RRL Jammu)

Global climate change poses a serious threat to living organisms and support systems. Although remedial measures such as reducing of greenhouse gases emissions by the industrialized nations have been undertaken around the world, some recent evidence suggests that the heat-trapping gases like carbon dioxide, produced mainly from the burning of fossil fuels, continue to raise temperatures, change the global climate, and affect ecosystems.

It has recently learnt that enhanced CO_2 *per se* may reduce plant growth and reduce sequestration of root-derived soil carbon when combined with other changing climate factors like, higher temperatures, increased precipitation or increased nitrogen deposits in the soil. Therefore still a lot is to be learnt about the factors responsible for carbon tapping in different natural ecosystems, and the importance of a multifactor experimental approach to understanding ecosystem responses to global change.

The strategy therefore calls upon addressing the issue across the diversity of resilient/ sensitive ecosystems, encompassing the vulnerable species in natural populations, and target agricultural crops of critical importance, besides creating new sinks in potential sites such as in the desert ecosystems. Under natural conditions, these could be challenging tasks, inviting basic research to tackle problems of low/ high temperature, besides aridity, and look for appropriate genes/ gene suits to develop suitable transgenics for the success of plant inhabitation.

Research focus

- Changes in plant species, soil microflora, and pollinators in different ecosystems (alpine and cold desert, coastal and wetland ecosystems) would be studied and simulation studies on the impact of climatic variables on target plant species in aforementioned four ecosystems would be conducted.

- Effect of CO2, temperature and other climatic factors on primary and secondary metabolism would be studied and stable metabolomes and their molecular basis for the isolation would be investigated so as to utilize genes for plant adaptation under environmental stress.
- The developmental biology of key/ vulnerable species would be studied and time series analysis (change detection studies) of natural vegetation in distinct bio-geographical regions using RS/ GIS techniques would be carried out. Finally Net primary productivity, CER credits, and carbon sequestration in different forest types would be reported.

Envisaged outcomes/outputs

- Infrastructure for Climate Change research
- Identification of keystone species for abatement against climate change in the proposed ecosystems
- Databases of ecological genomics.
- Human Resource Development for Climate Change research
- Efficiently deploying species for CER credits
- Transgenic plants for abatement against climate change
- Base line information in relation to climate change with regard the proposed ecosystems
- Knowledge on the integrated response of primary and secondary metabolism and fitness genes/ gene suits to climate change.
- Key mechanisms involved in seed development biology
- Potential species to serve as CO_2 sinks
- Strategies for decision making by governmental agencies for combating ill effects of climate changes
- Fitness genes/ regulatory elements.
- Knowledgebase for forecasting consequences of global change across multiple biological levels and varied ecosystems.

3.2.6.7 Environmental contaminants: New screening technologies and effect on human health (*ITRC*, CFRI, CFTRI, NBRI, NPL, IGIB, RRL-Jorhat)

Rapid industrialization, urbanization and modernization have led to an increase in the generation and release of contaminants in the environment. There is a growing awareness about role of chemical and biological contaminants in food and water in creating various human diseases. The potential toxicants in consumer items (food stuffs etc) are additives (adulterants) or other contaminants.

Similarly, people living near the mining and industrial belts are exposed to diverse groups of chemicals posing health hazards likely to affect the masses. A continuous environmental vigilance and interventional strategies by conventional and innovative methods will eventually minimize the health hazards of the masses.

Industries producing inorganic chemicals, fertilizers, dyes, paints, pharmaceuticals and batteries have been identified as hazardous since their wastes are non-degradable and difficult to recycle. Contaminants such as persistent organic pollutants (POP), pesticides, heavy metals and toxins of fungal and bacterial origin have received attention due to their ability to adversely affect human health and environment.

Upgrading the existing infrastructure facilities, innovative approaches to develop state of the art technologies to meet international as well as importing-country requirements, developing human resource in niche areas of risk based testing, and bio-monitoring at the national level is warranted.

Research focus

- The macro objectives of the project are development of newer, rapid and cost effective approaches for the following: (i) Environmental impact assessment, (ii) Abiotic and biotic monitoring and health risk and (iii) Food and water safety.

Envisaged outcomes/outputs

- New technologies for efficient rapid & sensitive detection and monitoring of environmental contaminants and risk assessment to detect trace amounts of chemicals/bio-contaminants that are not detectable by the available methods. The studies are expected to generate IPR on the newer assays/devices for the detection and amelioration of the contaminants.
- Prediction of potential toxic effects of contaminants. Industries such as dyes and colours, food and beverages, herbal products, textiles, plastics and polymers, mining and steel, thermal power will be benefited by the expertise generated during the program.
- The scientific and social outcomes of the project will definitely be of immense help in predicting and preventing the health ailments and thus will bring social and economic benefits to the society.

3.2.6.8 Mapping of the marine biodiversity along the Indian coast (*CSMCRI* NIO and NGRI)

India has a long coastline with coastal population of 370 millions, of which 17 million belong to fishermen community. Millions depend on estuaries and coastal seas for their sustenance, in terms of fisheries and other resources.

The coastal environment is receiving releases of industrial and sewage effluents. A serious concern has been raised regarding these issues in the recent times with reports of bioinvasive species occupying and causing serious bioresource-imbalances. The effects of anthropogenic activities (industrial, urban, coastal space encroachment, shipping related activities, etc), as also the natural causes such as coastal hazards, tsunamis, etc, are further manifested in unnatural occurrence of toxic algal blooms and depletion of reserve mangroves forests, seaweeds and coral resources

The data available to understand harmful effects on the marine biodiversity is patchy and contains several gaps in terms of temporal and/or spatial collections and analyses. These gaps should be eliminated rather quickly for delineating remedial measures for marine resources.

As a measure of biodiversity conservation also, there is a need for thorough biological investigations, which has been recognized all over the globe. The present network project has been proposed for working towards conservation of the marine biodiversity and would involve inventorying, cataloging, quantifying and mapping of the elements of biodiversity that include genes, individuals, populations, species, biotopes, ecosystems, and landscapes.

Habitat or ecosystem based approach will be adopted to understand different aspects of marine biodiversity. Critical habitats to be selected will include mangrove, seaweed, sea grass, coral environments as well as estuaries, backwaters, marsh, swamps and brackish water lake. Seven locations have been identified to represent such environments which are as follows: (i) Sikka (Gujarat) for mangroves & seaweeds, (ii) Okha (Gujarat) for Seaweed flora & microbes, (iii) Colaba (Mumbai) for seaweeds & microbes, (iv) Mandovi-Zuari (Goa) for estuaries, mangroves & seaweeds, (v) Kochi (Kerala) for backwaters and swamps-benthos, (vi) Gulf of Mannar (Tamil Nadu) for seaweeds and (vii) Godavari delta (Andhra pradesh) for Mangrove

Research focus

➲ Marine biodiversity including seaweeds, mangroves, benthos and marine microbes would be assessed using appropriate taxonomical and molecular tools, at selected habitats along the Indian coast for conservation and proper utilization of marine living resources. The project would create culture collection centres and prepare marine data base.

Envisaged outcomes/outputs

➲ Data base on marine biodiversity along the Indian coast would be developed.

3.2.6.9 Inhibition of quorum sensing and biofilm formation by marine algae and algae from high altitude: Potential for development of environment friendly antifouling agent (*CSMCRI*, IHBT)

Biofouling is the phenomenon whereby surfaces in contact with water are colonised by microorganisms, which are ubiquitous in our environment. Bacteria are the first organisms to foul surfaces exposed to (sea) water. Their subsequent multiplication and exopolymer production lead to the formation of biofilm.

The presence of primary slime surface attracts a large number of fouling organisms. Biofilms are complex associations of cells, extracellular products and detritus either trapped within the biofilm or released from the cells. Vessels of all sizes, both commercial and recreational, use antifouling paints to control the biological growth of target organisms on submerged surfaces. The traditional treatment strategies involve use of environmentally hazardous tributyltin (TBT). Although a total ban on the use of TBT coatings is not expected in the short terms, there is a growing need for environmentally safe antifouling systems.

One of the promising alternatives is to develop antifouling coatings in which the active ingredients are compounds naturally occurring in marine organisms and operating as natural anti settlement agents. The surfaces of some sessile benthic marine algae are heavily fouled, but the majority of the marine algal species, though living in the same ecological niche, are rarely susceptible to fouling, indicating the possible presence of antifouling mechanisms.

Recent studies demonstrate that both plants and algae can recognize the occurrence of N-acylhomoserine lactones (AHL)-signalling compounds in their environment and can disturb the communication of bacteria by secreting AHL-mimic compounds.

Based on recent findings, it seems very promising to screen a wide variety of marine algae for the occurrence of compounds that can mimic or interfere with AHL-bacterial signalling. These chemicals may have great potential to replace harmful chemicals to control bacterial development, e.g. bacterial growth on surfaces of ships, industrial water systems etc. In addition, these compounds have high potential value as future pharmaceuticals, because they have antimicrobial activity and may interfere efficiently with opportunistic and obligatory human pathogens.

Research focus

- Antifouling coatings would be developed in which the active ingredients are compounds naturally occurring in marine algae and operating as natural anti settlement agents. The Algae present in high altitude ponds of the cold desert will also be screened for the presence of AHL mimic substances and isolation there from.

Envisaged outcomes/outputs

- Development of environmentally safe natural antifoulant from Algae
- Development of bacterial detection system employing specifically constructed sensor strains with Lux R as receptor gene and gfp (green fluorescent protein) as reporter gene plus one or more genes for antibiotic resistance.
- Identification and characterization of the active compound from the positive extracts.

NATIONAL FACILITY CREATION

3.2.6.10 Sophisticated environmental analytical instrumentation facility (NEERI)

The problems of environment are ever increasing due to rapid growth of population and development activities in India. In spite of a series of regulations covering a wide range of pollutants, new and hither to unknown pollutants are invading due to anthropogenic activities, synthetic chemicals in environment, geo-bio-chemical changes and their movement in environment. Characterization of hazardous emissions, effluents and waste is a challenging task in the light of ever changing and stringent local and global/international regulations. Besides, the trans-boundary movement of wastes/ pollutants poses a serious problem.

To address and resolve a range of issues posed by pollutants and their health impacts and concerns, NEERI has taken recourse to Molecular Environmental Science as a Supra Institutional Activity. Appropriate measures are necessary to alleviate human health concerns in resolving the pollution problems at appropriate levels. The research support shall be through identification and quantification of pollutants at micro/nano levels of detection warrant sophisticated analytical infrastructure/facility development

Various regulations are in place in India and we need to fulfill the obligations of various criteria laid down in international conventions on pollution monitoring. Most of these regulations are having stringent norms but we do not have facilities developed for environmental monitoring and analysis especially in respect of the following: PCBs, Dioxins and furans, Monitoring of stack and incinerators, Pesticides residues, Hazardous chemicals and Hazardous wastes, etc.

Standard methods and instrumentation for analysis of some of the above pollutants are well known, but issues related to traceability, uncertainty and quality of analysis are posing serious problems. However, for some of the pollutants, standard methods are well known but instrumentation is rarely available due to high cost, sophistication and problems related to maintenance. For other cases of pollutants no facilities exists. In view of rapid economic growth envisaged in XI Five Year Plan, the environmental challenges have to adequately addressed with state or art facilities and appropriate QA/QC standards.

Analytical facility necessary for the objectives has been planned such that equipment along with sample preparation/inlet, storage, disposal, instrument calibration, data processing and remote access. In view of cost and dearth of specialised manpower high amount of automation has to be inbuilt in the instruments. Sophisticated instruments for material characterization are also required to develop solutions to the environmental problems through nanotechnology. Therefore facility for material characterization is essential.

Aim of the facility

- A sophisticated analytical instrumentation national facility for environment monitoring, analysis and assessment would be created including reference standards and QA/QC protocols for analysis and characterization for the following: (i) Reliable analysis of large number of samples for regulated and other pollutants with high precision, accuracy, speed and low costs, and (ii) Analysis of emerging pollutants and metabolites present at very low concentrations in different matrices and pollutants of human concern such as dioxins, furans, PCBs, POPs, PAHs, etc. for which protocols and methods to be developed

Envisaged outcomes/outputs

- Reliable and sophisticated analysis of environmental pollutants

Total Plan budgetary requirement projected for the Sector is Rs. 335 crore

3.2.7 ENERGY: RESOURCE & TECHNOLOGY

Over the years, increasing demand for energy could be sustained primarily through increased dependence on sources such as coal, oil, natural gas and electricity. India is not endowed with large primary energy reserves but has to contend with growing population and increasing final energy needs. The current assessment in regard to the primary commercial energy resources indicates that coal is the major energy resource of the country. However, the environmental issues related to use of coal based technologies restrict its use only to power generation. The oil was imported to cater burgeoning energy requirements, specially for transport sector. From US$ 33 bn in 2004-05, India's oil bill rose to to $43 bn in 2005-06 and is expected to cross $100 bn within next five years. If India is to become world power, issue of energy security attains the prime importance. This could only be achieved by basing the energy generation on safe, secured and assured resources available within the country. This could be done by gearing our R&D efforts to develop indigenous technologies based on resources available within the country, viz., coal, solar, wind and biomass.

Many CSIR laboratories are engaged in undertaking R&D and developing new knowledge and technologies in this strategically important sector. Today, it has emerged as a major

R&D agency with its laboratories contributing towards development of alternate sources of energy and technologies involved in their production, conversion and storage besides delivering incremental innovations in the area of conventional fuels. The programmes for the coming XI Plan broadly cover the emerging areas of photovoltaics, coal based technologies, batteries for diverse use, biodiesel development, biomass conversion to fuels and hydrogen economy which include two network projects 'Bioenergy technology: strategy designing of Jatropha curcas for biodiesel and a major Hydrogen economy initiative of CSIR; four proposals under interagency networking which include multi-kW planar SOFC system, lithium-ion batteries, underground coal gasification & IGCC technology and a composite approach for clean coal initiative;. 'R&D on photovoltaics, coal to liquid (CTL) technology, conversion and utilization of biomass to fuels, lubricants and additives and battery development and hydrogen production for cleaner and greener environment are being proposed for implementation under Suprainstitutional mode. Two proposals are for facility creation which includes fuel cell testing and validation facility and autonomous centre for battery testing. All theses programmes are focused on outcomes very relevant in Indian context and if India is to make significant advances in this sector.

SUPRA-INSTITUTIONAL PROGRAMMES

3.2.7.1 R&D on photovoltaics and other solar energy applications(NPL)

India is blessed with abundant supply of solar energy almost throughout the year. Solar energy (Photovoltaics) is the most promising alternative to the conventional energy sources. The main issue associated with crystalline silicon solar cells is to improve efficiency of large area from the present level of 14-16 % to 16-20% (AM1.5). In the case of amorphous silicon solar cells the major concerns are the cell instability and relatively low deposition rate of amorphous thin film. Recently organic solar cells are the subject of great interest all over the world where R&D efforts are aimed to find cost effective and easily processable alternative improve cell efficiency beyond the current level (~4%). At NPL, a large number of scientists have been involved in R&D in these areas and there exists a sound knowledge base and technical expertise. The proposed Supra-institutional project intends to consolidate the efforts to solve the above-cited R&D problems in the area of Solar Energy.

Research focus

- To improve large area crystalline and multi-crystalline silicon solar cells (η ~16-20%), create Solar Cell Characterization Facility for R&D & industrial use, develop large area a-Si/μc-Si monolithic 10% stable solar cell on low-cost substrates, develop conjugated polymers based solar and polymer based super capacitor as storage device, develop nano-structured meso-porous films of transition metal oxides, polymers & synthesis of organic electro-chromes for electro-chromic and photo-electro-chemical applications, prepare phosphors suitable for absorbing UV-Green part of solar spectrum and emitting in red and their application in solar cells, Solar selective coatings and development of CdSe and CdTe quantum dot solar cell using meso-porous TCOs.

Envisaged Outputs/Outcomes

- Development of thinner and improved solar cell structures so that the cell efficiency could be enhanced to 16-20% (AM1.5).

- Development of new phosphors that may shift the violet-green wavelengths solar spectrum to red region.
- Development of high rate deposition of microcrystalline silicon thin films (2.5 nm/s) and development of 10% efficiency stable solar cells.
- Development of super capacitors as storage device that besides finding applications in automobiles, may possibly also be integrated with polymer cells to provide solar cells which can function for some time even in dark.

3.2.7.2 Energy for cleaner and greener environment (CECRI)

With steep increase in crude oil price rise, it has become amply clear that developing countries like India should look for alternate energy sources which will not only cater the country's energy needs but are environmentally benign. Over the years, CECRI has built sound knowledge base and expertise in the area of batteries and hydrogen generation/ fuel cells. The project aims to develop indigenous and customized electrochemical energy devices, Polymer Electrolyte Fuel Cell stacks, Rechargeable Lead –Acid, maintenance free sealed Ni- Fe Batteries and Lithium-ion batteries as power sources for portable electronics, EV, HEV and pulse power applications in conjunction with other agencies.

Research focus

The objective is to develop indigenous and customized electrochemical energy devices, Polymer Electrolyte Fuel Cell [PEFC] stacks, rechargeable Lead –Acid, maintenance free sealed Ni- Fe Batteries and Lithium-ion batteries as power sources for portable electronics, EV, HEV and pulse power applications, micro- and flow line batteries, exploitation of nano chemistry to derive a nano road map for energy saving, conversion and storage applications, economically viable lithium technology, clean, green production of hydrogen for energy needs

Envisaged outcomes/outputs

Phase I: A 1-kW PEFC stack operating on hydrogen and air would be developed using cost-competitive and functionally superior components. This would be integrated with a suitable PEMWE capable of delivering 0.8 Nm3/h of hydrogen. Based on the results, necessary modifications would be made in the design and development of PEMWE and PEFC systems for the subsequent phases.

Phase II: A 2.5-kW PEFC stack would be developed. This would be integrated with a PEMWE capable of delivering 2 Nm3/h of hydrogen.

Phase III: A 5-kW PEFC stack would be developed. This would be integrated with a PEMWE capable of delivering 6 Nm3/h of hydrogen. Total integration with power conditioner, control and monitoring systems, and balance-of-plant would be carried out, and analyzed for process parameters.

Demonstration of 5-kW PEFC stacks operating on hydrogen generated from PEMWE.

3.2.7.3 To develop know-how and technology for environmental friendly conversion and utilization of biomass to fuels, lubricants and additives (IIP)

The project involves development and improvement of heterogeneous catalyst for biofuel, bio ethanol and technology for production of liquid fuels.

Research focus

The project aims to develop:

- heterogeneous catalyst for biofuel, bioethanol production from cellulose and starchy biomass by thermophiles,
- process and technology for the production of liquid fuels by fast pyrolysis of biomass feed stocks,
- process and technology for the production of hydrogen from bio oils produced from biomass feedstocks,
- production of hydrogen from carbonaceous feed stocks,
- adsorption technology for the recovery of carbon dioxide from gaseous stream in biomass gasification under conditions of high temperature and pressure,
- saccharides based bio degradable lubricants.

Envisaged outcomes/outputs

The envisaged deliverables/outcomes are:

- A continuous process for biodiesel based on heterogeneous catalyst.
- Process for the production of bio-ethanol from cellulose and starch using thermophiles.
- Process and technology for the production of liquid fuels by thermo catalytic conversion of biomass feed stocks.
- Process and technology for the production of hydrogen from bio oils produced from bio mass feed stocks.
- Process and technology for the production of hydrogen from carbonaceous material feed stocks
- Process for the gasification of carbonaceous feed stocks to produce syn gas/substituted natural gas for down stream processing.
- Adsorption technology for the recovery of carbon di oxide from gaseous stream in biomass gasification under conditions of high temperature and pressure.
- Process for the absorptive separation of carbon di oxide from gas stream of bio mass.
- Saccharides based bio degradable lubricants.

NETWORK PROJECTS

3.2.7.4 Bioenergy technology: Strategy designing of Jatropha curcas for biodiesel (*NBRI,* CSMCRI, IMTECH, RRL-Jorhat,RRL-Bhub, NCL,IIP)

Jatropha curcas has been identified as the most promising feedstock for biodiesel requirement at national level. Many labs of CSIR have been engaged in developing processes and technologies to provide quality biodiesel from Jatropha. The present proposal outlines objectives and methods in traditional and modern biology for developing elite materials, agro techniques for various site conditions such as alkaline, acidic, coastal, suffering from metal or fly ash toxicity; protocols for mass multiplication and transformation; development of processing technologies for converting oil into biodiesel; utilization of by product; alternative transesterification protocols etc..

Research focus

Under this project various CSIR labs will work on selection and development of elite varieties of Jatropha which has specificity for soil, climatic conditions etc. and are reqgion specific. Biodiversity inventorisation and metabolite profiling of accessions for marker identification will also be conducted. The project is likely to provide solutions in developing indigenous end-to-end process for production of biodiesel from Jatropha.

Envisaged outcomes/outputs

- Site adapted and selected germplasm with higher oil content; availability of agro technology package for optimization of oil yield (data for saline, alkaline, coastal and metal contaminated soil sites); availability of large number of plants for trials by macro propagation of selected germplasm
- Identification of markers for oil quality and quantity
- Availability of lines with contrasting genetic diversity
- Availability of protocols for in vitro micropropagation and embryonic culture
- Availability of protocols for transformation
- Identification of regulatory elements for carbohydrate to oil pathway
- Availability of lipase/s for optimal conversion of oil to biodiesel
- Availability of genotypes, mutants for oil-seed developmental studies
- Availability of protocols for utilization of cake as fertilizer and soil amelioration; energy conversion
- Utilization of glycerol for biodegradable polymers
- Availability of superior parent lines and segregating populations of specific crosses for future selections, stabilization and genetic enhancement of J. curcas
- Availability of technology for lipase mediated transesterification
- Up scaled trans esterification protocols using heterogeneous catalysts and full conversion of free fatty acids to biodiesel

3.2.4.5 Functional organic materials for energy efficient devices (*RRL, Trivendrum*, NCL, CLRI)

Various chemical laboratories of CSIR have been involved in synthesis of conjugated/ conducting polymers/ materials which may find uses in photonic, electronic and opto-electronic devices. The objective of the proposal is to develop novel functional organic materials, dyes and photo-chromic sytems, which can be used for a variety of photonic and electronic applications such as photovoltaic devices, light emitting diodes, imaging systems and optical memory discs and optical switches.

Research focus

To develop novel functional organic materials, dyes and photo-chromic sytems, which can be used for a variety of photonic and electronic applications such as photovoltaic devices, light emitting diodes, imaging systems and optical memory discs and optical switches.

Envisaged outcomes/outputs

- ➲ Development of functional organic materials, dyes and photo-chromics for photonic and electronic applications

3.2.4.6 Development of gas to liquid (GTL) processes for DME and fischer-tropsch fuels (*NCL*, IIP, CFRI)

Fischer Tropsch synthesis (FTS) has recently become a subject of renewed interest particularly in the context of the conversion of remote natural gas to liquid transportation fuels. The main incentives for gas to liquids (GTL) are the increased availability of natural gas in remote locations where markets do not exit nearby and the growing demand for transportation fuels. The proposed project envisages to develop indigenous GTL processes for new fuels which involves development of appropriate catalyst and process optimization for synthesis of DME from Syn Gas, development of GTL catalysts and process for synthesis of middle distillates and other fuels and setting up/ operation of pre-demonstration pilot plant for FT liquid and DME.

Research focus

To develop indigenous GTL processes for new generation fuels, networking with the following aims:

- ➲ Development of catalyst and process optimization for synthesis of DME from Syn Gas
- ➲ Development of GTL catalysts and process for synthesis of middle distillates and other fuels.
- ➲ Set up and operate pre-demonstration pilot plant for FT liquid and DME.
- ➲ Synthesis gas and hydrogen through CO_2 reforming from biomass derived materials

Envisaged outcomes/outputs

- ➲ The data generated in the single tube fixed bed reactor results would be further confirmed at process development unit (PDU) level, besides generating some basic design data.
- ➲ Scaling up from 35 L to 1m^3 reactor.
- ➲ Create a reliable facility in the country for any catalyst tests in GTL for taking up to commercial scale.
- ➲ Development of a catalyst and process for the slurry phase synthesis
- ➲ To create infrastructure for FT synthesis and facilities and knowledge base in catalysis
- ➲ To develop and processes for utilization of bio-gas that contains both methane and CO_2 at biorefinaries, molasses treatement plants, waste treatment plants etc.

3.2.7.7 Hydrogen economy initiative (*NCL*,CECRI, CGCRI, NPL, IICT,CSMCRI, CFRI,RRL-Tvm.)

There is a world wide interest to develop H_2 as an alternative source of clean fuel, particularly to use it as an anode fuel for fuel cells. Higher efficiencies of fuel cells, though help in reducing the CO_2 emission to the atmosphere to an appreciable extent, it still does not serve long term goal of protecting environment from CO_2 emissions. Hydrogen economy involves production, storage and conversion of hydrogen into energy. All the three aspects are proposed to be addressed adopting different routes.

Research focus

The project involves hydrogen production by hydrocarbon reforming, through water splitting using photocatalysts and electrolysis using polymer membranes coupled with renewable energy source. It also involves development of hybrid raw structured materials for hydrogen storage, advance generation membranes for polymer electrolyte fuel cells, integration of electrolysis unit with fuel cell and development of electro catalysts for electrolysis (PEMWE) and fuel cell (PEMHFC).

Envisaged outcomes/outputs

Hydrogen generation

- To produce hydrogen from conventional fossil fuels (CH_4, LPG and EtOH) using novel formulations of ATR catalysts
- To produce hydrogen by steam reforming of oxygenated hydrocarbons such as ethanol and glycerol
- To carry out aqueous phase reforming in a novel approach using nano structured Ni and Co catalysts and their alloys in a CSTR type reactor
- To develop monolith based water gas shift (WGS) and preferential oxidation (PROX) catalysts for ATR based fuel processor
- To produce pure hydrogen from LPG and autothermal reforming using CO_2 and hydrogen separation in Pd membrane reactor.
- To produce (100%) pure hydrogen from syngas using a singe step palladium membrane reactor and also develop defect-free cheap Pd alloy membranes.
- To design, develop and demonstrate a polymer Electrolyte Membrane Water Electrolyzer(PEMWE) capable of producing Nm^3/h of hydrogen.

Hydrogen Storage

- To prepare functionalized carbon nanotubes (CNTs) by chemical vapor deposition method and post-preparation treatments to form hybrid materials with different metal nanoclusters such as Pd, Pt to improve their hydrogen storage capacity
- Preparation of metal-oxide framework(MOF) structures using various design of hybrid organic-inorganic multilayers by self-assembly and to characterize these hybrid materials with and with out the presence of hydrogen; Synthesis of Alanates and other solid materials with enhanced hydrogen storage capacity and moderate regeneration conditions

Hydrogen conversion using fuel cells

- Development of 5 kW PEMFC stack operating on hydrogen and air with indigenous materials under ambient Pressure
- To develop novel membranes for PEM based fuel cell that would have high thermo-mechanical stability, have lower fuel crossover, high CO tolerance while exhibiting high proton conductivity.
- Development of energy efficient and cost effective components for PEMFC like graphite-polymer composite based bipolar plates and porous carbon papers with alternative routes
- To prepare new electro catalysts for oxygen reduction reactions
- Development of anode, cathode, sealant and interconnect materials for planar Solid Oxide Fuel Cell technology
- To develop new materials for intermediate temperature(700 0C) solid oxide fuel cells

3.2.7.8 Development of coal to liquid (CTL) technology for synthesis of liquid from hydrocarbons (*CFRI,* IICT,IIP*)*

India has huge coal reserves. CFRI has been in the forefront of generating new knowledge and gained expertise over the years in coal and coal based technologies. Coal to liquid (CTL) technology has recently attracted attention of energy planners owing to steep price rise of crude oil. Having the background in coal, CFRI intends to further built its knowledge base and core competence by proposing this project to develop indigenous know-how/process/catalyst/new systems for CTL technology for efficient utilization of remote/stranded coal and thereby converting it to liquid hydrocarbons.

Research focus

- Gasification of Indian coal.
- Purification of coal gasifier gases (ie removing Hydrogen sulphide, ammonia, carbon dioxide etc.)
- CO_2 – reformation of methane for syn gas production.
- (By conventional heating & microwave heating)
- Developing suitable catalyst for coal gasifier gases.
- (For low H_2/CO ratio & impure gases)
- FT- reaction in micro-channel reactor (Ceramic Monolith) for increasing throughput, reducing size of the reactor & better heat control.

Envisaged outcomes/outputs

- Developing indigenous know-how/process/catalyst/new systems for CTL technology
- Efficient utilization of remote/stranded/low quality Indian coal by converting it to liquid hydrocarbons.

INTER – AGENCY PROGRAMMES

3.2.7.9 Development of a composite approach suitable for clean coal initiative (*CMRI,* CMERI, CFRI, RRL-Bhubaneswar, NML, CSIO, CEERI, BHEL- Kolar)

Clean coal initiatives have become essential in view of the delirious impact on environment, climatic change and ecology of coal mining, processing and uses. The project aims at addressing the issues that are related to clean coal technology (CCT) in mining, preparation/beneficiation, and combustion/utilization stages of coal life cycle.

Research focus

The project aims at addressing the issues that are related to clean coal initiatives essential in mining, preparation/beneficiation, and combustion/utilization stages of coal life cycle. The objectives envisaged are to develop a composite approach for clean coal initiatives which include clean coal mining, clean coal preparation and clean coal combustion/utilization.

Envisaged outcomes/outputs

- Technological package for fast extraction of this quality coal from the virgin seams or standing pillars from underground coalmines under different geo-mining conditions
- Technology for stowing and filling of underground voids

- Techno-economic viability of the beneficiation circuits/process to produce clean coal of desired quality for various end users
- Technology of oxy fuel combustion of pulverized coal for achieving near zero emissions from coal based electricity generation
- Technology for co-combustion of pulverized coal and biomass for reduction in CO_2, SOx and NOx emissions

3.2.7.10 Development of multi-kW Planar SOFC system for operation below 800°c having multi-fuel capability (*CGCRI,* NML, CMERI,IIT-Khargpur, IIT-Mumbai, BHEL-Hyderabad)

Compared with other type of fuel cells, Solid Oxide Fuel Cells (SOFC) characteristically has all solid state components providing compactness and flexibility to design. In addition, high operating temperature (> 700oC) makes possible fast electrode reaction and no need for expensive catalysts. CGCRI has developed competence and expertise in this area. Although the SOFC technology is presently at an advanced stage of development in a few developed countries like USA, Germany, Australia, Canada, Japan, etc., it being highly promising, is one of the well-guarded technologies and therefore needs to be developed indigenously where participation from various organizations having expertise in different areas relevant to the development of the total technology is required. Keeping all these factors in mind, the proposed project aims to develop a multi-kilowatt SOFC stack (including system design) based on the state-of-the-art anode-supported design with participation from various laboratories and industries under a network program.

Research focus

- To develop state-of-the-art anode-supported thin film electrolyte planar SOFC single cell, Multi-kW stack (up to 5kW) and total SOFC system including balance of plant.

Envisaged outcomes/outputs

- Development of the internationally competitive technology based on the state-of-the-art anode-supported planar SOFC stack with total system in multi kilowatt range capable in operating with H2, natural gas and biogas.

3.2.7.11 Development of Lithium-ion batteries for multifarious applications (*CECRI*, RRL-BHUB., NPL, CGCRI, IIT-Khar., INDOCEL-Bangalore, NED-Hyderabad, HEB-Trichy)

One of the critical challenges of twenty-first century is unquestionably energy storage. With a view to address the needs of today's information-rich e-society and the emerging ecological concerns, it is reasonably urgent that economically and environmentally benign energy conversion and storage systems are to be identified and exploited. CECRI envisages developing indigenous rechargeable lithium-ion batteries with emerging category battery components that are perfectly engineered to exhibit high energy and high power density characteristics in order to best suit the needs of total portable energy packs and electric vehicular traction applications.

Research focus

The project aims at:

- optimizing synthesis methodologies for battery grade materials,

- low-cost synthesis methodologies for lithium battery electrode/ electrolyte materials for possible upgradation to bulk production,
- characterization of electrodes/electrolytes and selection of high-performance electrode/electrolyte materials,
- improvement of rate capability behavior and cycling stability and built-in safety with suitably engineered materials and flexible designs

Envisaged outcomes/outputs

- Development of indigenous synthesis processes for energy saving electro active materials / electrolytes
- Indigenously fabricated energy devices, viz., fuel cells, Lead- acid batteries and Lithium batteries for consumer market based and zero emission needs
- Wind energy based 200kW hydrogen generator

3.2.7.12 Development of underground coal gasification and IGCC technology in India (*CMRI*, NML, NCL, NGRI, IIP, BHEL, Department of Petroleum, The Singareni Collieries Co.Ltd.)

The common notion of the desirability of large coal deposits to make a UCG Project economically viable is not strictly valid. A number of factors may combine to make a block economically more viable than the other. One of the strategies of coal gasification is to employ high temperatures for more complete gasification of coal and production of less tar. So this needs high demands in coal characteristics. The Under Ground Coal Gasification (UCG) is a technology for recovering energy contents of coal by gasifying the in situ coal deposits. Integrated Gasification Combined Cycle (IGCC) is an alternate to pulverised coal combustion for power generation. A combination of UCG and IGCC is technically feasible. Underground coal gasification (UCG) using oxygen and steam system is expected to be more economical as it gives better process efficiency and yields better quality gas as compared to that with air and steam systems, specially in the case of deep seams. Efforts will be made to investigate the effect of oxygen and steam content of the injected stream on the composition of the product gas. CMRI proposes to take up the project in association with several other agencies/laboratories and internationally accepted UCG-IGCC experts.

Research focus

The main objectives would be to select a suitable coal block, precise exploration in the selected UCG block and evaluation of the coal seam characteristics, coal permeability, cleat density, fracture length etc. and then creating high permeability zones between injection and production wells, igniting the coal, injection of oxidant such as air/oxygen/steam down the injection well, passing the gas through the permeable path in the coal seam and producing combustible gases and pyrolysis products from the product well, assessment of composition and heat values of the producer gas and effect of temperature and pressure on heating value, establishment of a power station of appropriate size wherein the product gas will be used as a feedstock for electricity generation and demonstration of the UCG-IGCC technology.

Envisaged outcomes/outputs

It is proposed that the project will be undertaken by CMRI in association with SCCL. The project will be executed in different phases summarised below:

Phase-I	Identification of suitable blocks for UCG-IGCC blocks.
Phase-II	Exploration for gassiness studies in the identified UCG blocks, evaluation of coal seam characteristics, petrographic make up etc.
Phase-III	Drilling of injection and production wells, interconnection of wells, igniting the coal, injection of oxidants, production of gas and other gasification operation.
Phase-IV	Linkage of the product gas to IGCC power generation.
Phase-V	Evaluation of performance and modelling and demonstration for a longer time period at optimum efficiency.

FACILITY CREATION

3.2.8.13 Development of fuel cell testing and validation facility (NCL, Pune)

The fuel cell performance is influenced by physical parameters of different components of the fuel cells irrespective of the size and type. The proposal envisages to create skills, competence and facilities in testing, evaluation and standardization of hydrogen and fuel cell technologies in terms of efficiency and reliability to facilitate wider market introduction; to assess and validate technology improvements and develop commonly agreed measures for system efficiency such as power density, dynamic behavior and durability; to define and validate test procedures for fuel cells / components for different applications and provide customers with reliable / trustworthy basis for comparison of fuel cell performance and to standardize the testing methods and conditions leading to authentic data generated at different institutes or organizations

Envisaged outcomes/outputs

- Testing and validation of all types for fuel cells and their subsystem components
- Development of guidelines for systematic assembling of the fuel cells and stacks and the preliminary and performance testing
- Performance analysis of the fuel cells as a function for different operating conditions
- Testing and evaluation of individual fuel cell components, single cells and multi-cell stacks in terms of performance and operational characteristics.
- To determine the performance of small fuel cell modules and individual subcomponents with respect to performance rating.

3.2.8.14 Autonomous Centre for Battery Testing (ACBT) (CECRI)

Indian battery manufacturers require evaluation of batteries as per national and international norms. With a view to extend the available knowledge base and expertise available with CECRI in the field, creation of Autonomous Center for Battery Testing is proposed. The types of battery that can be handled are: Pb-acid, Ni-MH, Li-ion and Fuel cells. At present, gas handling systems (fuel cell testing) are not included.

Aim of the facility

- Creation of data bank on different types of battery and on EVs and EV batteries
- Identifying market potential for battery Evaluation, including estimation of export potential
- Identification of performance parameters for batteries and helping in the formulation of Industrial

- Standards and specifications.
- Characterization facilitates for battery materials and evaluation of battery components.
- Carrying out of R&D activities pertaining to battery evaluation and development of newer materials for batteries.

Envisaged outcomes/outputs

- Certification to the clients
- Knowledge dissemination through training programmes-
- Development of expertise in battery testing

Total Plan budgetary requirement projected for the Sector is Rs. 628 crore

3.2.8 ELECTRONICS, PHOTONICS & INSTRUMENTATION

India has the potential to develop and manufacture electronics / IT hardware for the global markets and gain higher global share besides meeting the country's future requirements. As a result of technological convergence at the infrastructure, services and industry levels; there has been a tremendous up-surge in new products. A major contribution to the growth of electronic industry has been driven by innovations in microelectronics, opto-electronic devices, chip components, sensors, information storage and retrieval devices, flat panel devices etc. The value of electronics goods production in India (which include: consumer electronics, industrial electronics, computers, communication & broadcast equipments, strategic electronics and components) during the year 2004-05 was at Rs. 1524.20 billion and it is estimated to touch Rs. 1856.60 billion in the year 2005-06. During the year 2005-06 electronics and IT exports were estimated to be Rs. 1117.00 billion as compared to Rs.881.80 billion in 2004-05. This has opened up an enormous opportunity for the Indian industry in this sector.

CSIR recognized the long-term significance of the crucial role of electronics in the overall national development, initiated R&D efforts in this area as early as in the fifties. Today, it has emerged as a major R&D agency with its laboratories contributing towards various aspects of electronics and instrumentation. The competence developed over the years and synergy built with the system during the last few years , CSIR aims to focus its activities / progrmmes for the Eleventh Plan would be in the areas of: MEMs & Microsensors; High Frequency Microwave tubes; Solid State Lighting; Photonics for communication, laser & sensor technology; Instrumentation for Agriculture, Food & public safety applications. These programmes will be implemented in network mode and all theses programmes are aimed at macro objectives with significant contribution to the socio-economic & strategic sector. The supra-institutional projects that would help synergize the in-house capabilities include; Technology development of smart systems and Technological Solutions for Societal applications. In these programmes majority of the groups within the laboratory would participate to maximize the outputs.

SUPRA-INSTITUTIONAL PROGRAMMES

3.2.8.1 Technology development for smart systems (CEERI)

The world is entering a new age of technology with Smart Systems. Smart Systems and Smart Embedded Realtime Systems incorporating different types of sensors with associated signal conditioning and necessary processing together with communication/networking/RF networking interfaces are being used used in configuring different application specific systems.

The activities during the XIth plan will include the setting up of MEMS characterization facilities and development of appropriate electronic signal conditioning and signal processing circuitry for the microsensors developed at CEERI. The developed modules will have all the features of smart/intelligent sensor and will be able to act as modules of a bigger system. The proposed project aims at developing Smart Systems for spurious drug detection, industrial quality control, disaster detection in mines etc.

Research focus

Design and development of algorithms, techniques, modules and prototypes of smart systems for variety of applications like defect identification in industrial process, material classification, spurious drug detection, industrial quality control and security system.

Envisaged outcomes/outputs

- Development of algorithms, techniques, modules and prototypes of smart systems and smart embedded systems based on image processing and processing of inputs received from variety of sensors utilizing soft computing, fuzzy, neural and artificial intelligence techniques and wireless networking capabilities.
- The modules to be developed would include modules for signal conditioning, linearization and temperature compensation for different sensor devices and incorporation of communication/networking/RF networking interfaces with sensors.
- The algorithms, techniques and modules developed would be integrated into prototype smart systems for a variety applications such as image based defect detection in industrial processes such as steel rolling, image processing for authentication of medicinal herbs, smart cameras that can identify and track objects, hazard sensing and warning generation in mines, disaster detection and location in mines and electronic nose and electronic tongue.

3.2.8.2 Technological solutions for societal applications (CSIO)

Sensors and Systems play a key role in various sectors of human endeavour and advanced sensor technology has been identified the world over as one of the critical technology for the future. These systems find applications in every segment of human endeavour covering health, agriculture, advanced manufacturing systems, avionics, optical communications, space satellites, super smart highways, biotechnology, genetic engineering, pollution control, diagnostics and so on. The technology of sensors has gone through revolutionary changes and their evolution is a continuous process. Newer class of sensors with innovative features is superseding the conventional sensors.

Research focus

To design and develop Instrumentation For; diagnostics, therapeutics & life support systems, prosthetics & prosthesis, earthquake early warning, landslide monitoring, railway safety, characterization of various agro/diary products for quantification of quality, standardization & calibration of sensors and actuators, and standards & calibration facilities for health care.

Envisaged outcomes/outputs

- Instrumentation systems for; Diagnostics, Therapeutics and Life support systems, Prosthetics & Prosthesis
- Instrumentation for; Early warning for Earthquakes and Coastal Hazards, Landslide and Snow Avalanche monitoring, Distributed fire safety sensor and Railway Safety Instrumentation
- Instrumentation for quantification and quality of agro & dairy products
- Standardization & Calibration of Sensors and Actuators
- Standards & Calibration Facilities for Health Care

NETWORK PROJECTS

3.2.8.3 MEMs and Microsensors for requirements in food, health environmental and social sectors (*CEERI,* NPL, IHBT, CCMB, NCL,RRL-Bhopal, CGCRI,CFTRI,CSIO,CMERI)

Sensors and Microsensors based on the concepts and applications described above are being widely researched in the developed countries. Some of these sensors have also recently begun to become available on a commercial basis while other sensors are likely to become available/commercialized during the next 5-7 years. The large need of compact, easy to use, low-cost sensors in sectors like food, crop health, health, environment, soil and water is widely recognized by the users in these sectors. Individual CSIR laboratories have their individual expertise in the area of materials/device structures/characterization aspects/domain knowledge relating to sensors. The project aims to tie up all these strengths together into the development of micro-sensors for specific applications described above.

Research focus

Development of Microsensors for detection of heavy metal ions and pesticides in food, toxic and noxious gases in atmosphere, bio-sensors, compact drinking water analyzers and laboratory-on-chip for chemical and bio-logical applications.

Envisaged outcomes/outputs

- The developed materials/technologies and devices would be used to build, test and characterize sensors for the following applications:
- Detection and quantification of anti-oxidants, traces of pesticides (organo phosphorous), traces of toxic heavy metals (lead, cadmium, mercury) in different food and environmental matrices.
- Development of cDNA based crop/virus group specific chips for plant virus detection for agri–horti areas (for viruses infecting apple, carnation, chrysanthemum, economically important vegetable crops and orchids)
- Gas sensors for noxious and polluting gases (Co, NoX, NH_3, H_2S) in mines and environment.
- Bio-sensors : For Glucose, Cholesterol, Triglycerides, Dopamine, Ascorbic Acid and Uric Acid in Physiological Conditions.
- Micro-total analytical systems for capillary electrophoresis and chromatography.

3.2.8.4 Design and fabrication capabilities for very high power, high efficiency and very high frequency microwave tubes (*CEERI*, CGCRI,CSIO,NPL)

There is a huge demand of these devices for various applications at the agencies like DRDO, ISRO and DAE in the foreseeable future. CEERI has developed expertise in design and development of all types of conventional Microwave Tubes like Magnetrons, Klystrons, Carcinotrons, Traveling-wave Tubes (Both Helix and Coupled Cavity types) and other non microwave tubes like Power Triodes, Thyratrons and other Plasma Devices. Since the advanced technologies and products being developed by the developed countries in the area of Microwave Tubes are not accessible to us (due to strategic reasons), the same must be developed within the country.

Research focus

Development of techniques, methods, materials, parts and subassemblies for use in high CW Power Microwave Tubes and fast wave devices needed for important national programmes.

Envisaged outcomes/outputs

- Establishment of Design, Fabrication Facilities, and development of design skills fabrication techniques, characterization methods, specialized materials and development of sub-assemblies of High CW Power single beam and multi-beam klystrons (100 KW CW power upwards), Pulsed Magnetrons (3 – 5 MW pulse power), Gyrotrons (110 GHz, 200 KW CW), Travelling Wave Tubes (for terrestrial and space applications), UV/Vacuum Ultra Violet (VUV) sources and new generation high frequency Microwave Devices (>100 GHz Frequencies) and associated power/Pulse Power systems.

3.2.8.5 Fabrication of led devices and systems for solid state lighting applications (*NPL*, CEERI, CSIO, RRL-TVM, IICT, CECRI)

The Solid State Lighting (SSL) market is seen to cross 8-10 billion USD by 2010. Though the theoretical luminous efficiency is 673 lum/watt, applications in today’s market reliably involve only upto 30-40 lum/watt, and are still being used extensively in mobile phone, signs, automotive, traffic, signals, etc.

Though their application in ‘illumination’ (lighting) is now only 5% world over, the prognosis for the demand for this application is to go up by leaps and bounds. It is forecast that by 2010 most of the incandescent and by 2020 the fluorescent lighting will be replaced by Light Emitting Diodes. Obviously, with the operating efficiency only about a twentieth of the full potential, there is an enormous scope for R & D in terms of advancing the luminous intensity, operation life, quality of light, cost, versatility and safety. Major world laboratories and industries are already in this business in a big way, and are acquiring the Patent portfolios at a brisk pace.

Research focus

To develop the technology of Gallium Nitride material growth and the technology of LED device fabrication using the grown material with the objective of developing prototype solid state lighting source.

Envisaged outcomes/outputs

- III-V Epilayers on suitable substrates with defined specifications
- Growth of high quality doped Epitaxial multi-layers
- Deposition of organic multi-layers suitable for OLED
- LEDs of defined specifications
- Development of Standards (measurement protocols)
- Development of suitable display, automotive and lighting systems for direct applications

3.2.8.6 Photonics for communication, sensor and laser technology (*CGCRI,* NAL, CEERI, SERC, RRL-Tvm.,)

The WDM-amplifier and FTTH market in India as well as abroad is growing exponentially, the proposed programme for developing DWDM optical amplifier and FTTH components will be a novel proposition under the proposed programme. The fibre Bragg grating (FBG), represents an attractive alternative for structural health monitoring (SHM) applications. In India, the demand of fibre lasers for material processing in industry and medical purposes is expected to grow at a very fast rate in the coming years. The advantages and precision with which the fibre lasers can execute the job will largely outperform the necessity of solid state lasers in such fields. Biophotonics activities are yet to start in the country, it is expected that through the proposed activity a concerted effort can be initiated to cater the need of the related core research groups and bio-tech industries.

Research focus

The objective of the project is to initiate programmes in the areas of Photonics and Opto-Electronics. The projected tasks envisage developments of few key technologies and devices which will play a vital role in the future communication and sensor technology and also in strategic field.

Envisaged outcomes/outputs

- Development of DWDM Optical Amplifier and Components for Fibre To The Home (FTTH) Technology for modern optical network system.
- Development of Fibre Bragg Grating based sensor system for civil and strategic applications.
- Development of high power fibre laser for industrial applications.
- Development of special type Photonic Crystal Fibre (PCF) for Super-continuum generation and high power laser
- Development new materials for Bio-sensing and Bio-nanophotonics.

3.2.8.7 Instrumentation for applications in agriculture, food and public safety (*CSIO,* IHBT, CFTRI, CEERI, IMT, CMERI, CBRI, ITRC, NPL, CGCRI,CRI,NGRI,RRL-Jorhat)

Innovation to improve agriculture productivity and public safety systems is continuously evolving with the availability of novel and smart materials, intelligent transduction techniques and recent advances in signal processing strategies. The ability to incorporate information concerning the operating characteristics of the sensors is becoming more prevalent and it is now possible to combine the sensors along with system integration.

Research focus

The proposal is aimed at development of advanced instrumentation systems and related sensors with the above mentioned features in the two sectors: Agri & Food and Public Safety. These systems shall be internationally competitive or superior to their contemporaries in the next five years.

Envisaged outputs/outcomes

➲ Agriculture& Food productivity

Pre-harvest Instrumentation:

- Cultivation under controlled environments.
- Natural resource management - Soil parameters, drip irrigation with micro-nutrient control.
- Tissue culture instrumentation.
- Specific Metabolic Monitoring.

Post harvest Instrumentation

- Monitoring, Control and Networking of Storage Houses.
- Environmentally Controlled Manufacturing of Medicinal Plants.
- Systems for sorting & grading of fruits & vegetables

Instrumentation for food processing

- Industrial fermentation
- Process optimization
- Quality assessment

➲ Public Safety:

- Geo-seismic Sensors
- Data mining applications
- Civil structures health monitoring
- Detection of explosives. Organic vapours and bio-agents

Total Plan budgetary requirement projected for the Sector is Rs. 372 crore

3.2.9 ENGINEERING MATERIALS. MINING/MINERALS & MANUFACTURING TECHNOLOGY

India is endowed with a large variety of mineral resources. Of the 84 minerals it produces, four serve mainly as fuel, 11 are metallic, 49 non-metallic and 20 minor minerals. The total mineral production in India is approximately 463 million tones (Rs. 635.404 billion) against a global production of about 9768 million. Among other metals produced in the country, iron and its alloys have a major contribution to the economy. India today is the ninth largest crude steel producing in the world. However, India does not produce high-grade ores of several metals like NI, Cu, Co, Mo, Zn, Ag, Au etc. therefore its dependence is mainly on lean grade and complex ores and sometimes even on the waste materials and secondaries. Overburden/lean and off grade ores are with mineral fines, slime and tailing from mineral industry are a major source of waste, disposal of which is a serious problem.

Indian manufacturing companies are targeting global markets and are becoming competitors. India's advantage goes beyond labour, into capital productivity and better process knowledge. The workforce in the manufacturing sector constitutes nearly 45 million (11% of the workforce). The total output from the manufacturing sector is nearly 450billion US $ contributing to 16% of GDP. 0ne job created in manufacturing in turn creates 2-3 jobs in service sector. The sector contributes 53% of exports, 32% of composition of food beverages, tobacco and chemicals followed by textiles, basic metals rubber and petroleum. The sector attracts 79% FDI and it has registered a growth of 8.1% in April-September 2005. However, it is a matter of concern that the contribution of manufacturing to GDP has remained stagnant for over two decades since 1985. One of the major reasons has been India's inability to build and maintain competitiveness needed to meet the global challenges as well as to develop a larger domestic market through low cost production. The low levels of manufacturing growth had its adverse impact on employment generation.

CSIR as an R&D provider has tremendous responsibility to contribute significantly in the growth of this sector which on one hand creates wealth and on the other has the potential for large scale employment generation. Thus under the Eleventh Five Year Plan, the project alignment is linked to these national priorities. The prime focus of this strategy is to bring innovation in material and manufacturing process. The approach is aimed at ; Development of New Materials, New Process, Flexible Manufacturing, Efficient harvesting of material & mineral resources and Skill development linked to national imperatives such as; Energy, Environment, and National Security, Distributed development, Globally competitive market oriented technology. Towards achieving these objectives a Cluster approach has been undertaken. Most of the R&D programmes in this sector would conform to the objectives as enshrined in the cluster mandate. These cluster are:

(a) Advanced Structural Material : Light weight metals & alloys and Ceramics & composites.

(b) Electronic materials

(c) Nano-materials

(d) New Process: Extraction & material development, and Manufacturing

(e) Flexible Manufacturing

(f) Efficient harvesting of minerals and materials: Energy and non-energy minerals/materials

(g) Bio-medical materials

As the focus of the programmes and activities of the sector in the Eleventh Five Year Plan would encompass the needs and innovativeness under the above cluster groups. The objectives of the cluster groups shall be achieved through strong networking of CSIR laboratories and also working with institutions/agencies outside CSIR in network mode and in multi disciplinary areas.

SUPRA-INSTITUTIONAL PROGRAMMES

3.2.9.1 Development of specialty glasses for strategic and industrial application (CGCRI)

Special Glasses have always played a crucial role in Nuclear Research and Defense Applications. During 10th five year plan period CGCRI has been able to sustain and augment the infrastructural facility to implement the projects related to specialised glasses to meet the country's need. For the Eleventh Plan, programmes have been formulated to continue these activities further and to carryout R&D for development of newer glasses to meet the future requirements of Nuclear Research, Space and Defense applications. The outcomes of this project will be able to meet the requirement of DAE for large size phosphate laser glass rods and discs, development of chalcogenide glasses, and knowledge base for developing the glasses for phtonic and opto-electronics.

Research focus

- Process Optimization of Laser Glass Melting and setting up of a Large Scale ($\sim$ 40 Kg) Processing Facility.
- Development of high concentration Er–doped glass for use as solid state green laser medium.
- Development of chalcogenide glasses for use in infrared optical and opto-electronic devices.
- Simulation and Modeling of Glass Melting Phenomenon.
- Refurbishing and Modernization of the Glass characterization facilities.

Envisaged outputs/outcomes

- Supply of large size phosphate laser glass rods and discs as per the requirement of the Dept. of Atomic Energy.
- Establishment of a fully equipped laboratory suitable for development of chalcogenide glasses and creation of the knowledge base for developing the glasses for photonic and opto-electronic applications.
- Knowledge base for the process optimization through simulation and modeling.

3.2.9.2 Ceramic materials for emerging technologies involving liquid and gas separation (CGCRI)

Concern for environment and global warming resulting from the use of excessive quantity of fossil fuel is increasing day by day. Generation of clean energy is, no doubt, going to be one of the greatest challenges during the Eleventh Plan. While newer methods of energy production will come to fore, maximizing the efficiency of the existing production methods is going to be an important issue. Energy efficient production technologies are going to receive much greater emphasis than ever before. In many of these endeavors, membrane based separation technology will be receiving more and more attention and for that purpose ceramic membrane, compared to conventional polymeric membrane, would certainly assume a very significant role.

Research focus

- Creation of knowledge base on the fabrication of newer ceramic membranes and membrane reactors for liquid and gas separation applications.

- Development of devices/prototypes using functional coating materials based on amorphous ceramic oxides, zeolites, partially substituted Perovskite for hydrogen separation, combustion/partial oxidation process and CO_2 removal.
- Preparation of proton conducting ceramics usable at elevated temperature for fuel cell and hydrogen production from water vapour.
- Prototype development using SiC based tubular substrate from Celluloses material for coal based IGCC technology.
- Development of ceramic membranes based process technology particularly in brewery, sugar industry, dairy and vegetable oil industry.

Envisaged outputs/outcomes

- Zeolite based membranes fabricated in the desired shape and size suitable for separation of different gas mixtures of importance in the area of energy and environment.
- Dense membranes with mixed ionic and electronic conductivity useful either hydrogen or oxygen separation.
- Sic based hot gas filter for IGCC technology.
- Ultra / nano filtration membrane based technology for different industrial application.

3.2.9.3 Capability development in manufacturing of mobile robotic system for National Security Disaster Management and Hazardous Applications (CMERI)

Research and development of Mobile Robot for outdoor, strategic and industrial application is gaining momentum in India. A large amount of R&D work has been reported in the literature by various academic and R&D institutions in India and abroad relating to indoor mobile robots. Generally the application of indoor mobile robots is limited to factory automation and materials handling. However, the outdoor mobile robots are more flexible and demand of the day due to its application potential for multiple and multirole civilian applications.

Research focus

- To develop capability, knowledge, Technology and Expertise in mobile Robotics through field deployable Prototypes for;
- Rescue mission
- General Surveillance, Inspection & Handling
- Explosives & Hazardous Material Handling
- Environment & Industrial Applications

Envisaged outputs/outcomes

- One experimental & two field deployable model of the serpentine Robot. (Endurance: 30 Min, Vehicle speed 0.5-1 m/s, Communication Radio Frequency)
- One experimental & one field deployable model of the compact out door Robot (Vehicle Speed 1 m/s, Endurance 2.5 hrs, Max. Slope Climbing 25^o)
- One experimental & two field deployable model of the Flying Robot. (Operation speed :80 Km/hr, Dry Weight 25 kgs, Pay load 5 Kg (Approx)
- One demonstrable prototype of the out door mobile Robot, (Speed 1 m/s , Pay load 25 kgs, Endurance 3 hrs)
- Facility creation for development of mobile robotic systems

3.2.9.4 Development and forming of performance driven special steels (NML)

Metallic materials have largely been developed through empirical correlation of processing and properties. In recent times, implementation of materials science principles within a systems approach framework has led to a paradigm shift from materials science and engineering to scientific engineering of materials. This is of particular importance for the case of steel, which continues to be the highest tonnage (90%) metallic material produced and used. India today is the ninth largest crude steel producer in the world. However, steels with ultra high strength and/or high formability combined with favourable mechanical properties, have not been developed in India commercially in spite of their high demands in structural, space, automotives and strategic sectors. Innovation and improvements in steel will be required to secure the continued dominance of steel in these sectors.

This project aims to foster indigenous development of special steels targeted towards specialty applications through a comprehensive approach integrating alloy design, processing, characterization and evaluation of product performance. Development of such steels will be facilitated by a virtual platform for alloy design taking into consideration of non-equilibrium thermodynamics, precipitation kinetics and property predictive algorithms. A variety of melt processing methodologies, with emphasis on steel cleanliness and control of gaseous impurities, and on solidification, will be attempted. Special and novel alloy processing to enhance the bulk and surface properties, will be carried out; this would include Nano-precipitates strengthening, Severe Plastic Deformation (SPD), Accumulative Roll Bonding (ARB), Surface Mechanical Attrition (SMAT). Enhancement of surface performance by surface engineering through plasma and laser modifications, development of specialty coatings and grain boundary engineering will form an important facet of the programme.

Research Focus

- Development of special steels through systems approach based alloy design and processing (e.g., nano-phase dispersion, severe plastic deformation, etc.)
  - ultra high strength for structural and strategic applications
  - high formability special steels for automotive and aerospace applications
- Development of light-weight steel foams for spatial structures with emphasis on increased energy efficiency and safety
- Development of thermomechanical, thermochemical and advanced forming processes for special steels
- Development of advanced joining protocols for specialty steels
- Development of surface modification technologies for specialty steels to enhance surface and sub-surface properties.

Envisaged outcomes/outputs

- Ultra high strength steel [Yield strength upto 1600 MPa, Ultimate tensile strength > 2000 MPa, Elongation > 8%]
- Alternate special steels through alloy variation, thermomechanical processing

- ➲ Virtual platform for alloy design
- ➲ Light weight steel foams for improved fuel efficiency and passenger safety
- ➲ Expertise in advanced joining of developed special steels
- ➲ Surface engineered and surface modified special steels

NETWORK PROGRAMMES

3.2.9.5 Technology for assessment and refurbishment of engineering materials and components (*NML*, CMERI, CGCRI, SERC, NPL, CRRI, CBRI, NAL, RRL-Bhopal)

Critical engineering materials and components are designed to withstand normal "wear and tear" during their service lives. Safe operation even under abnormal service conditions is often factored into their performance in order to minimise human and economic penalties that may accrue under exigent situations. In spite of this, operational failures continue to be responsible for frequent forced outages, break-downs and loss of production in the engineering industry. At the other end of the scale, overemphasized conservatism in design and plant and operation management results in useful life and service capacity to be still left in engineering components for continued operation when they are retired from service.

Twelve activities are being proposed under the project. The activities span the generic areas of non-destructive evaluation, microstructural characterization, oxidation, erosion, creep, fatigue and fracture, and surface engineering. The scope of the activities have been planned to address state-of-the-art concepts and techniques, and contribute incrementally to gap areas of knowledge. Wherever necessary, stress will be laid on adoption and indigenization of appropriate technologies, in preference to *ab initio* research.

Research focus

To develop technologies, processes and protocols for the assessment of damage and refurbishments of performance and life in engineering materials and components.

Envisaged outputs/outcomes

- ➲ Development of non-destructive evaluation (NDE) protocols (non-linear ultrasonic and acoustic emission) for assessment of damage in components of petrochemical industries and power plants
- ➲ Development of sensors (magnetic, FBG, PZT etc.) for NDE of pressure vessels and piping and remote structurals
- ➲ Damage quantification and NDE of critical concrete structures
- ➲ Minimally invasive and miniature specimen testing techniques for damage characterization of critical components
- ➲ Multi-dimensional modelling of microstructural degradation of engineering materials
- ➲ Development of advanced joining techniques for dissimilar materials of automotive and aerospace components
- ➲ Simulation, modelling and mitigation of oxidation-corrosion and oxidation-erosion damage in thermal power plants
- ➲ Development of material and coating technology for mitigation of silt erosion in hydroelectric power plants

- ➲ Fatigue and fracture characterisation of nuclear power plant materials and components for enhanced safety considerations
- ➲ Surface engineering for enhancement of life of automotive components
- ➲ Surface engineering and modification for components of petrochemical industries
- ➲ Life extension practices for aircraft components
- ➲ Structural health monitoring of aircrafts & smart air frames

3.2.9.6 Development of advanced lightweight metallic materials for engineering applications (*RRL-Bhopal*, NAL, NML, NPL, RRL-Tvm.)

Lightweight materials are set to become an integral part of the emerging technologies in the country. Development of new classes of materials having increased strength, lighter weight, greater resistance to combinations of severe physical, chemical and complex loading environments, and improved acoustic, thermal resistant, insulating, temperature withstanding properties are a great challenge for scientists. All these factors should be compounded with the cost competitiveness in the new global economy setting. This challenge can be successfully tackled by thorough understanding on the fundamental relationships that link compositional balance in the input material properties and process methods for improvement in the product composition, microstructure, and defect structure through experimental and computational routes.

Some of the thrust areas where lightweight materials find preference are in engineering applications including automobile and aerospace industries where substantial use of aluminium, magnesium and titanium alloys and composites has enabled reduced component weight and improved fuel consumption. The areas of application are many and varied. Realizing the importance of the lightweight materials in different sectors, it is proposed to develop lightweight and high strength materials having special properties.

Proposed Research focuses on experimental, theoretical and computational modeling studies to understand the influence of fundamental parameters on development of light weight materials, understanding on the material phase formation, micro structural evolution, and their resulting properties.

Research focus

- ➲ Special casting techniques for Al and Mg based alloys and metal matrix composites: twin roll casting, low pressure casting, centrifugal casting, squeeze casting, compo-casting, semisolid processing etc.
- ➲ Powder metallurgy processes for Ti based alloys and hipping etc.
- ➲ Development of conductor grade Al alloys and effect of rare earth elements in Al alloys.
- ➲ Development of amorphous light alloys.
- ➲ Process simulation, modeling and design.
- ➲ Simulation module for 3-D mold filling during casting and prediction of the solidification profile
- ➲ Sheet metal forming, electromagnetic forming, rolling, forging and extrusion of tubes and rods.
- ➲ Die and Process Design.
- ➲ Cellular materials like Al/Mg foam.

Envisaged outputs/outcomes

(i) Technologies/Processes:

Casting techniques:

- Twin roll casting ;Low pressure casting;Squeeze casting;
- Semisolid processing; Continuous foam making;Centrifugal casting

Deformation processing

- Extrusion; Rolling; Forging; Electro Magnetic Forming; Sheet metal forming; Hipping

(ii) Conceptual deliverables

Material design; Die design & Manufacturing; Microstructure and process ; simulation; Simulation module for 3-D mould filling during casting; Microstructural and deformation mapping

(iii) Demonstrative materials

- Mg alloy & Mg alloy composites; Amorphous / ultrafine grained light (Al & Mg) alloys; Al alloy ultrafine particle dispersed composites; Ti alloys and Ti alloy composites; Cellular materials
- Crash worthy metal foam – Ti, Al foam for aerospace applications
- Al & Li alloys – Impact resistant leading edge over Ti

(iv) Demonstrative component

Light alloy sheets; TiB2 coated electrodes for Al extraction; High strain Al-alloy conductor for electrical transmission; Ti alloy compressor disc; Piston: Brake drum; Connecting rod; Engine block; Fuel access door cover; Automobile crash box; Rural climatizer; Bio-implants

3.2.9.7 Non-oxide ceramic based advance structural materials: Armours and Refractories (*CGCRI*, RRL-Bhopal, NML)

Glass, ceramics and ceramic-based composites, due to their favourable mechanical and thermo-mechanical properties, are, in a sense, ideal armour materials for the protection of personnel and infantry vehicles against ballistic attack. It is worth mentioning that during the 10th plan period CGCRI could develop a number of exotic ceramic materials suitable for such ballistic application. In the 11th plan it is proposed to take this activity to its logical conclusion in developing ceramic armours for body and vehicular protection. This activity will be carried out in close collaboration with defense R&D organisation of the country.

Research focus

- Development of personnel armor based on FRP-Ceramics composite structure.
- Fabrication of polymer-ceramic layered composite panels for the armored vehicles.
- Investigation of the fracture behavior of the composite structures under very high strain rate conditions.
- Simulation and Modeling of the crack propagation phenomenon in these materials.
- Investigation of aluminium alloys for armour application.
- Setting-up of a unique laboratory outside DRDO system for investigating the high strain behavior of materials

Envisaged outputs/outcomes

- Technology development and supply of armor components as per the requirement of the defence department.
- New knowledge base in the area of fracture behavior of composite structures under high strain rate conditions.
- Know how generation for development of new materials to be used as steel melting refractories.

3.2.9.8 Development of electronic materials and devices (*NPL*, CGCRI, RRL-Tvm., RRL-Bhub.,NML)

Electronic materials are the class of materials of which the components making up electronic products are made. Some of the products that contain electronic materials are computers, TV's, radio, radar, microwave devices, flat panel displays (FPD), micromechanics and microsystems (MEMS), solar cells, lasers (in particular semiconductor lasers), batteries, accumulators and energy storage systems in general, sensors, fuel cells and magnetic memories.

Quite clearly, the development of electronic materials for a variety of applications is an essential field of R & D activity, which alone can enable the building up of indigenous capability for the development of novel devices and systems. The tremendous progress made by China in recent years in developing their indigenous capability for the fabrication of advanced devices and products, which enables them to flood the markets of countries like India with their cost-competitive products, shows that there is need for development of electronic materials.

Research focus

- To develop nanophosphors for photo- and electro-luminescent display applications.
- To develop MgB_2 and Bi2223 superconductors based high current carrying electrodes and multifilamentary wires/tapes for high strength magnets.
- To develop process of growth of lithiumniobate and other non linear optical crystals.
- To develop Ferrolelectric liquid crystals for application in spatial light modulators.
- To develop colossal magnetoresistance materials and ferro fluids for applications in magnetic devices.
- To develop different oxide materials and sulphides for electronic and optoelectronic applications

Envisaged outputs/outcomes

- Technology for preparation of nanophosphor materials for white LED, electroluminescent panels, luminescent panel for field emission devices, etc.
- HTS (Bi-2223/Bi-2212) electrodes for carrying more than 1KA current, Ag-clad multifilamentary tapes for HTS magnets.
- High field 14 Tesla Superconducting Magnet and Cryogen-Free 5 Tesla Superconducting Magnet.
- Technologies for production of MgB_2 multifilamentary wires and superconducting current leads (ratings upto 1000 A).
- Realisation of SFMO based room temperature magnetic sensor.

- Substrates for Microwave ICs and Electronic Packaging materials.
- Temperature stable high Q high k dielectric resonators for mobile phone base stations.
- Technology of growth of large diameter (upto 40 mm) undoped and Fe, Mg, Zn doped Lithium niobate (LN) single crystals and organic and semiorganic single crystals. .
- Durable and repeatable ophthalmic coatings on plastic lenses.
- Economical, energy efficient and user friendly processes soft chemical process of making precursors and materials (nano-particles and/or films, fine powders) for opto-electronic, dielectric and magnetic applications.
- Hydrogen sensor for safety during storage and transportation of hydrogen
- Moisture sensors for transformer oil and breath analysis for COPD (Chronic Obstructive Pulmonary Disease) patients and
- Polycrystalline and oriented PZT thin films in capacitive structure for sensor and memory applications by Radio Frequency Magnetron Sputtering and characterization

3.2.9.9 Nano-structured materials *(NML,* CGCRI, NAL, NPL, NCL, RRL-Tvm, RRL-Bhub, CCMB)

Materials play an important role in the progress of science & technology and the human society. Emergence of novel processes helps in tailoring materials with desired capabilities. Recent advancement on materials has been focused on the development of nanophase as well as nanomaterials and composites with improved physical, chemical, mechanical and biological properties. The innovative routes that are used to develop these nanomaterials are Chemical Synthesis, Self Propagating High Temperature Synthesis (SHS), Biomimetic Synthesis, Plasma Coating, Rapid Solidification Process (RSP), Severe Plastic Deformation (SPD) and Mechanical Alloying (MA). The occurrence of nanostructure significantly enhances the functional as well as the mechanical properties of the materials.

The project aims at development of nano-structured materials in the areas of; magnetic materials; bio-materials; ceramics and coatings, bulk nanostructured materials; catalyst and catalyst carrier; and environmental effects on and of nanostructured materials.

Research focus

(i) Development of nanostructured materials to achieve improved and tailored functional and structural properties

- Nanostructured Magnetic Materials
- Nanostructured bio-materials
- Nanostructured ceramics and coatings
- Bulk nanostructured materials
- Nanostructured materials for catalyst and catalyst carrier
- Environmental effects on and of nanostructured materials

(ii) Development of components or devices using nanostructured materials

Envisaged outputs/outcomes

- Materials for high temperature (> 600^{o}C) magnetic application
- Core materials for SMPS transformers, common mode choke coils
- Nanocomposite and coatings with hardness >30GPa
- Wear, oxidation resistance materials for high temperature
- Hard coatings with tunable band gap for optical window application

- Phosphors for flat panel display, light emitting devices
- 500W Stacked SOFC and PEMFC
- Oxidation resistant coatings on metals and coloured coatings on glass and steel
- Hybrid nanocomposite materials for dental filling applications
- Superhydrophobic coatings for self cleaning applications
- Hydropholic and hydrophobisc nano coatings for aerospace applications

3.2.9.10 Light weight metals and alloys : beneficiation, extraction and material development for structural use (*NML,* RRL-Bhub, CECRI, RRL-Bhopal, RRL-TVM, NPL, NAL)

Minerals are valuable natural resources that are finite and non-renewable. They constitute the vital raw materials for many basic industries and are a major resource for development. Hence management of mineral and other resources should be closely integrated with the overall strategy of development and exploitation of these resources must be guided by the long term national goals and perspectives.

Under this project novel beneficiation and extraction techniques for Titanium, Magnesium and Aluminum shall be developed. These novel processes will be used for the development of; titanium alloys and forming technology; magnesium alloys and composite development for automobile and aerospace applications; forming process for magnesium alloys including twin roll casting; aluminum alloy components for automobiles and continuous foaming technology for aluminum.

Research focus

(i) Beneficiation and Extraction

Titanium

- Production of high grade ilmenite from beach sand
- Novel extraction techniques for titanium extraction from ilmenite as the raw material without conventional rutile route (electrometallurgical and pyrometallurgical)
- Extraction of titanium using direct electrolytic reduction of titanium dioxide in molten electrolyte

Magnesium

- Development of commercially viable extraction technology for magnesium, e.g. continuous Pigeon process, and continuous electrothermal process
- Development of an indigenous technology to produce magnesium from sea bittern

Aluminum

- Novel techniques for environmental friendly leaching of bauxite
- Production of high purity aluminium from commercial aluminium
- Technologies for synergistic usage of wastes from aluminium industry
- Life cycle assessment/analysis of aluminum production and reduction in green house gases
- Novel technology for recycling of aluminum scrap

(ii) Material Development

Titanium

- ➢ Development of titanium alloys and forming technology

Magnesium

- ➢ Magnesium alloys and composite development for automobile and aerospace applications
- ➢ Forming processes for magnesium alloys including twin roll casting

Aluminum

- ➢ Novel forming techniques for production of components for automobile and aerospace applications
- ➢ Novel processing routes (thixo casting, rheo casting, centrifugal casting, equi-channel angular pressing)
- ➢ Continuous foaming technology

Envisaged outputs/outcomes

(i) Beneficiation and Extraction

- ➲ Flowsheet/ Technology for the recovery of high grade ilmenite concentrate and other mineral values from Indian beach sand through physical beneficiation
- ➲ Processes technologies and knowledge base for pigment and non-pigment applications of TiO_2
- ➲ Process for production of Alumina mono-hydrate from Bayer liquour
- ➲ Improved Bayer's process based on mechano-activation of bauxite
- ➲ Novel Process for electrothermal magnesium extraction
- ➲ Fuse salt electrolysis process for magnesium extraction from anhydrous magnesium chloride
- ➲ Low temperature electrolytic titanium production technology
- ➲ Laboratory and plot scale development of technology for extraction of titanium metal using direct electrolytic reduction of titanium dioxide in molten electrolyte
- ➲ Electrolytic process for super-pure Aluminum production
- ➲ Pollution mitigation and recycling protocols

(ii) Material Development

- ➲ TiB_2 coated electrodes for Al extraction
- ➲ Thixo & Rheocast Mg and Al alloys and composites
- ➲ High strength conductor grade aluminium alloys
- ➲ Improved mechanical processing techniques for Mg and Ti alloys
- ➲ Thermal barrier coatings for Ti alloy compressor discs
- ➲ Improved light alloy thin sheet production technology
- ➲ Near-net shaping technologies
- ➲ Enhancement of Ti based bio-implants
- ➲ Light metallic alloy foams
- ➲ Amorphous, nanocrystalline and ultra fine grained light metallic alloys
- ➲ Ti spongs for aerospace applications

- Joining dissimilar material for aircrafts applications

3.2.9.11 Cutting edge technologies for materials and resources conservation (*NML*, RRL-Bhub, SERC, CBRI, ITRC, NEERI, CEERI, CECRI,)

Recycling is endowed with several merits such as conservation of natural resources including minerals, huge energy savings, reduction of green house gas emissions and solution to waste disposal problems. The outlook of recycling varies from one country to another. For any country it is essential that the technologies available are eco-friendly, efficient, compatible and fulfill the requirements of the recycling economy. However, in most cases compatible technologies for efficient recycling and utilisation of man-made wastes are not available causing significant environmental pollution and inefficient utilisation of waste materials resulting in substantial depletion of naturally occurring minerals and resources. Hence development of such compatible technologies will contribute significantly towards minerals and resource conservation in India.

Research focus

- Development of Integrated technology for the processing of electronic waste
- Geopolymer mediated solutions for utilisation of industrial solid wastes
- High volume utilisation of fly ash in PPC through mechanochemical activation
- Comprehensive technology for the recovery of high value metals from spent catalysts from petrochemicals and other sources
- Technology package for recovery of valuable metals from used batteries
- Envisaged outputs/outcomes
- Integrated technology for the processing of electronic waste to recover precious/high value metals and recycling/utilisation of non-metallic constituents
- Technology packages for (a) self glazed geopolymer tiles, and (b) pavement tiles using low temperature (room temperature to100 ^{o}C) processing
- Development of technology for geopolymer cements of tailored properties for quick repairing of critical structures, fire resistant materials
- A process for safe stabilisation of toxic waste from metallurgical industries using geopolymer matrix.
- Technology package for high volume utilization of fly ash in Portland Pozzolana Cements
- A comprehensive technology for the recovery of high value metals (Co, Ni, Mo, W, V) from spent catalysts from petrochemicals and other sources
- Technology package for recovery of valuable metals (Ni, Cd, Li) from rechargeable batteries

3.2.9.12 Capability building of advanced manufacturing processes of value added components (*CMERI,* CGCRI, NML, RRL-Tvm, RRL-Bhub., NAL)

Over the years worldwide many groups participated in developing new processes and methods for the manufacturing of value added components on these lines. The competition among manufacturing nations to provide this quality has greatly intensified recently, underlying the need for on going, state of the art research in these areas. Continuous growth of technological development needs the high performance component manufacturing technique with exotic properties. Development of component with application characteristics is chiefly concerned with basic understanding between structure and correlation with improves performance. The fundamental physical, chemical and tailored properties of materials greatly influenced with the characteristics features with respect to scale. The process is to develop component of advanced materials with micro & nano-scale feature itself a challenging task which is a predominant exercise under the 11th plan.

Research focus

The prime objective of this program is to develop different manufacturing techniques for developing value-added engineering components for the application in automotive, aerospace, general engineering and bio-medical application.

Task-1: Development of manufacturing process through advanced Casting methods:

Task-2: Development of manufacturing process through Powder Metallurgy (CIP/HP/HIP) routes followed by post processing:

Task-3: Development of Metal-ceramic and ceramic-ceramic joining /coating process:

Task-4: Alternate materials for aircraft compnents

Envisaged outputs/outcomes

Task-1: Development of manufacturing process through advanced casting methods:

- Advanced Engineering components through Pressure assisted/ vacuum Investment Casting process
- Quick product realization through RP integrated Investment casting/ Gel Casting route of metals and ceramics
- Advanced shaping technology through Low Pressure Casting & centrifugal casting for functional graded alloys & composites

Task-2: Development of manufacturing process through Powder Metallurgy (CIP/HP/HIP) routes followed by post processing:

- Manufacturing process of High performance toughened ceramic cutting tool inserts for high speed machining
- Manufacturing process of Carbides, Nitrides and carbonitride powders through extended arc plasma reactors for wear resistant structural application
- Producing diamond powder from inorganic & organic sources by plasma technology
- Manufacturing process for advanced cermets and ceramic composites for cutting tools & wear resistant application
- Net shape manufacturing of advanced engineering components of metal & ceramics through RP integrated Gelcasting followed by machining

Task-3: Development of Metal-ceramic and ceramic-ceramic joining /coating process:

- To develop suitable joining & coating process through Transient Liquid./ Solid Phase Bonding, Infiltration/Reaction forming and sol gel process of metals & ceramics
- To develop new joining process (Microwave joining technique)

Task-4 : **Alternate materials for aircraft compnents**

- Gear and cylinder system of aircraft
- Helicopter transmission crank shaft
- Titanic fasteners

3.2.9.13 Modular re-configurable micro manufacturing systems (MRMMS) for multi material desktop manufacturing capabilities (*CMERI,* CSIO, CEERI, NAL)

Miniaturization has dominated every walk of life, mobile phones, palm sized computers, micro engines, and micro machine tools, artificial organs etc. have been developed in the recent years. The rationale behind the miniaturization is material saving, lower drive power due to low inertia and high degree of process controls and displacements of mechanical systems. Microsystems also add to the smartness, leading to small and handy products. Microsystems have found wider applications in automotives, micro controllers, space, medical, process control, etc. Biomedical implants are one of the key applications in which Microsystems are being used for many purposes including drug delivery, diagnostic, and biotechnology. However, Manufacturing of micro devices for bio applications differ from IC manufacturing, because the market requires a diversity of material, physical structure, input/output methods, and production of critically lower volumes per product. Hence, development of micro manufacturing systems having wider flexibility for multi materials and application has become the essential need in micro/nano domain.

Research focus

The primary objective of the overall program is to develop modular and flexible manufacturing systems for multi material micro systems/devices. The important components of the targeted micro factory test bed includes development of:

- Miniature machine tool/s for micro milling, micro EDM and laser machining leading to micro factory test bed.
- High speed air and magnetic bearings for micro machine tools
- Micro Controllers and diagnostics systems
- IPMC or SMA based handling system for micro factory manipulations
- For concept proving, the following multi material micro systems will be developed using the developed micro manufacturing capabilities.
- PCB based micro generator

Envisaged outputs/outcomes

- Re-configurable Micro factory test bed
- One demonstrable Concept proving component viz PCB Integrated micro Generator.
- Nano-sized ceramic powders for micro fabrication.

3.2.9.14 Development of advanced eco-friendly, energy efficient processes for utilization of indigenous mineral resources (*RRL-Bhub*, NML, RRL-Tvm., RRL-Jorhat)

There has been an unprecedented growth in mining and mineral industries since 2003, after passing through two decades of recession and stagnation during 1980 – 2000. Driven by an ever spiraling growth in demand, this sustained resurgence has caught the mining and mineral industry off guard. The reason is that more than 20 years of stagnant prices left most of the industry unprepared to cope with this sharp turn around. There was massive cut back on development of mines, exploration of new resources, development of equipment and processes for handling of ores below the existing cut-off grade. In 2003, the mining industry began its upturn and since then the industry is catching up in terms of exploration for new projects, development of new mines and processes. In Orissa alone forty-three MOUs have been signed for new exploration projects and development of new mines. Today, there is inadequate capacity to produce minerals as demand has increased. The project aims to provide advanced eco-friendly and energy efficient processes for utilization of indigenous mineral resources.

Research focus

The main objective of this program is to develop advanced eco-friendly and energy efficient processes and to enhance the economic competitiveness of our industry for the utilization of indigenous mineral resources.

Envisaged outputs/outcomes

- Process know-how for the beneficiation and utilization of low grade iron ore (cut-off grade: 52% Fe):: Al_2O_3 (<1.2%), SiO_2 (<1%) and P (0.02%) from low grade ores and fines.
- Process know-how for complete utilization of slimes and tailings.
- Process know-how for acidic clays; Technology for geo-synthetic clays and hollow clay sphere; Process technology for clay polymer composites.
- Complete mapping and process know-how for harvesting and value addition to beach sand minerals.
- Process know-how to obtain high purity graphite (>99% fixed carbon) and colloidal graphite.
- Process know-how for extraction of platinum group metals.

3.2.9.15 Development of improved process package and equipment for maximizing clean coal recovery and waste utilization (*RRL- Bhub*, NML, CFRI,RRL-Bhopal)

The energy requirement in various industrial sectors — iron, steel, cement and allied industries will continue to remain high and only coal can meet this demand economically. Therefore the dominant role of coal in energy consumption in metallurgical industries and power generation is likely to continue for decades. If quality coal can be produced at reasonable cost, the Indian coal industry hopes to flourish in future. The Ministry of Coal has assessed the demand for coal as 545 MT in 2006-07 whereas the production is expected to be only 443 MT. The demand for coal is expected to be 715 MT in 2011-12. A massive increase in quality coal production is needed in next twenty years to meet the growing demand of various industrial sectors, notably for iron & steel, aluminum and electrical power generation. Most of the Indian coals are of inferior quality with high ash and low calorific values. At present, India is importing around 19MT of low ash coal to meet the quality norms. This will increase further due to increase in power generation and production in various industries. The legislation of Govt. of India precludes transport of coal having more than 34.0% ash beyond 1000 kilometers from the pit head, which in turn envisages beneficiation of non coking coal to a great extent. Advanced beneficiation techniques are therefore highly essential to improve the quality of indigenous coal for its effective utilization.

Research focus

The main objective of this program is to develop efficient and cost effective process techniques and equipment to enhance the quality of indigenous low-grade coal for metallurgical, power and allied industries.

Envisaged outputs/outcomes

- Improving the efficiency of existing washeries through process simulation and modeling and to verify the possibility of producing clean coal with 10-12% ash at acceptable yield.
- Recovery of additional clean coal from the middlings of existing coking coal washeries for use in steel sector with increase in the yield. More judicious use of LVC coal for steel plant use rather than thermal power generations.
- Development of control system for process equipment to improve the performance of washeries.
- Complete utilization of washery rejects.
- Development of dry beneficiation techniques for high ash non-coking coal to reduce ash below 34% suitable for power generation.
- Process development to reduce ash to less than 25% starting from non-coking coal with ash content as high as 40%, for use in sponge iron and cement industry.
- Process development for production super quality clean coal for blast furnace injection.
- Development of design package for Modular Coal Beneficiation Plant having capacity of 3-5 lakh tones/annum for sponge iron and cement sectors.
- Process development in pilot scale for production of high purity non-coking coal for blast furnace injection.

3.2.9.16 Development of suitable biomaterials and process techniques for preparation of patient specific implants for rehabilitation (*CGCRI*, CMERI, NML, NAL)

In a highly populated country like India, health care is an important issue to be concerned about. In that context, glass and ceramic materials have certain important role to play particularly as effective bio-medical implants. During the last 10 years, CGCRI has made very significant contribution in this area including successful transfer of certain technologies e.g. alumina based hemi-hip joint and hydroxyapatite based orbital implant (artificial eye). It is therefore appropriate to continue this activity by way of developing more such implants with different functionalities at relatively low cost if possible. The requirement of knee and other joints, artificial teeth and bone fillers are also significant and at the moment the entire demand is met by imported implants at high cost. As a consequence, it is necessary to take a quantum jump in our health care infrastructure. The development of the state of the art prosthesis for treatment/rehabilitation of huge ailing population of the country within an affordable price is of paramount importance. The projects formulated under health care aim to achieve these objectives, by pooling the expertise available in various CSIR laboratories.

Research focus

- ➲ Development of alumina-based total knee arthroplasty.
- ➲ Development of dense hydroxyapatite-based ideal middle ear ossicular prosthesis.
- ➲ Development of ceramic-based bio-implants for spine disorder.
- ➲ Development of polymer-ceramic based composite-scaffolds of tailored properties through bio-mimetic / conventional route for cartilages.
- ➲ Development of process technology and its standardization for development of patient specific functionally graded components of metal/ceramic /composite based prosthesis from CT-Scan data and their detailed in-vitro characterization.
- ➲ Development of metal/ceramic/composite-based components to treat spine disorder including slip-disc/hard-tissue and cartilage problems and their in-vitro functional characterization.

Envisaged outputs/outcomes

- ➲ Total 3-component knee prosthesis including cartilages.
- ➲ Development of middle ear ossicular prosthesis.
- ➲ Development of metal/ceramic/composite based components for revision surgery of spine (cervical, thoracic and lumbar) including disc problems.

NATIONAL FACILITY

3.2.9.17 Centre of excellence on plasma processing of minerals and materials (RRL-Bhub)

In India the importance of plasma process technology for minerals and materials can hardly be exaggerated. Few institutions are at present engaged in the plasma related R&D. RRL, Bhubaneswar is the only laboratory in India engaged in mineral processing by thermal plasma for value addition. RRL, Bhubaneswar, which identified and started plasma processing as a major R&D activity as early as 1985, contributed substantially in minerals, materials, and allied areas. The *Advanced Materials Technology Department* which pursues plasma research is now equipped with various plasma facilities for carrying out process development in minerals and materials catering to industrial needs of the country. No other institution in the country does have such kind of facility for industrial plasma research.

Aim of the facility

Research at the Center for Plasma Processing (CPP) will be aimed to improve the basic understanding of plasma synthesis, processing, and properties of plasma processed materials. The targeted staring material will include minerals for value addition, waste, powders for coating. CPP shall provide research facilities, an equipment base and a support infrastructure that will enable scientists, students and industry professionals to conduct successful, team-oriented research and development projects. Finally the center shall provide a focus for interdisciplinary research and interactions with industry.

Envisaged outputs/outcomes

- ➲ Cost effective and eco-friendly technology for continuous production of nano powder using plasma source
- ➲ Plasma process for making powders of various industrially important minerals and materials.(TiO_2 pigment and catalyst, metal powder, SiC, SiN powder)

- Plasma process for making sintered product of different sizes. (Rocket nozzle, ceramic cutting tools, spinel etc.)
- Plasma process for making strategic alloys and composites.(FeCr, FeNi FeTiC, FeAlC etc.)
- Nitriding of gears and shafts.
- Plasma process for treatment of wastes. (Medical, Municipal and industrial waste)

3.2.9.18 Advanced centre on mechanochemistry and reactivity of solids (ACMRS)-(NML)

Mechanochemistry and Mechanical alloying is a frontier area of research. A number of institutes/centres/departments in countries such as Russia, Germany, Slovakia, Japan, Australia, and Italy are exclusively dedicated to research in this field. In India, mechanical alloying is being pursued in several academic and research institutes. However, in the area of mechanochemistry applications for mineral processing and waste utilization, NML/CSIR is the only laboratory which has taken lead through initiation of number of programmes with a long terms perspective. Some of the important progremmes/project along with their current status are listed below:

- Mechanical activation of bauxite to improve the performance of the Bayer process (sponsored project from NALCO pursued as part of 10th plan, a novel process have been developed using a batch type mill, research is in progress to revalidate results in a continuous type mill).
- Mechanochemical Activation in Improved Blended Cement Processing (Focus : BF slag, Fly ash). (This project was sponsored by CSIR under NMITLI programme. Significant interest in research results shown by industry within India and abroad to take up the project from 'proof of concept' stage to scaling up of the processes developed).
- Geopolymers for building construction materials (The products have been developed at lab scale and efforts are being made for setting up of a demonstration plant and scaling up).
- Processing of beach sand minerals (ilmenite, zircon) (Laboratory studies in progress on mechanical activation, characterisation and leaching of minerals)
- Extraction of chromium from chromite ores (work being pursued to explain the occurrence of chromium in mine water and find solution to associated environmental problems)
- Bioleaching of deep sea nodules
- Attrition milling of materials (basic studies in progress)
- Simulation of weathering processes (new dimension to the discipline of Mechanochemistry, work being done on chromite)

Aim of the facility

This Centre to evolve from the concerted efforts of NML in the area of mechanical activation of solids over half a decade will focus on the development of novel metallurgical and materials processes, in particular, an environmental friendly Bayer process for extraction of alumina, high purity rutile from ilmenite, processing of zircon sand, mechanical alloying, high tech ceramics, geopolymers and improved blended cements. The activities of the Centre on technology development will be supported with parallel fundamental studies on the reactivity of solids involved. Additionally, the Centre will focus on the simulation of weathering processes through mechanical activation to address some of the environmental problems, e.g. toxic elements in mine water. The Centre through its activities would aim for international recognition as a Centre of Excellence.

Envisaged outputs/outcomes

- Technology package for the utilisation of high volume utilisation of mechanically activated fly ash in blended cements
- Large scale testing and on-site demonstration of the utilisation of reactive blast furnace slag
- Commercially viable environmental friendly continuous process as substitute for the existing Bayer's process of alumina production
- Novel extraction processes for rutile from ilmenite, and low temperature chemical decomposition of zircon
- Novel processing advance alloys and ceramics through mechanical activation
- Training programmes and workshops
- Organisation of an international conference (VIth International conference on 'Mechanochemistry and Mechanical Alloying (INCOME2008)' as a part of biannual international series of conferences under the aegis of International Mechanochemistry Association

Total Plan budgetary requirement projected for the Sector is Rs. 850 crore

3.2.10 PHARMACEUTICALS, HEALTHCARE & DRUGS

The Indian pharmaceutical sector post 1970 has made a remarkable impact on the economy as well as global positioning of the country. Today India has about 20,000 pharmaceutical units in organized and small scale sectors which meet about 95% of country's pharmaceutical needs with the industry currently valued at approximately $ 8.0 billion. After India becoming fully TRIPs compliant the focus of the industry has shifted to product development through cutting edge R&D. The outsourcing opportunities in the pharmaceutical sector continue to grow due to cost competitiveness and IPR compliance and are globally estimated to be of the order of $ 55 billion in 2006. This represents a major opportunity for India.

CSIR has emerged as a major R&D driven multi-institutional agency in this sector as indicated by the fact that many Indian as well as foreign companies seek CSIR collaboration in the frontier R&D areas of drug discovery. These collaborative efforts afford a big and challenging opportunity for CSIR. Recent advances in biology such as genome sequencing have opened up unlimited opportunities in medicine. After deciphering sequence of genes (structural genomics), it is now possible to elucidate their function (functional genomics). Ultimately it is believed that through proteomics and new disease markers, the drug targets can be identified that will help in design of products to prevent, diagnose and treat diseases. All these tools and techniques and research disciplines are now being applied in R&D programmes of CSIR laboratories in order to become internationally competitive

The competence developed over the years and synergy built with the system during the last few years, CSIR aims to focus its R&D activities / programmes for the Eleventh Plan in the areas of cell & tissue engineering, identification and validation of drug targets and animal models, drugs & diagnostics for asthma, bioinformatics approaches for the development of software tools to be used in drug discovery process as well as for diagnostic applications, study of type-II diabetes at genetic level for relevant drug discovery ,development of nanomaterials and nanodevices etc. . These programmes will be implemented in network mode and all these programmes are aimed at macro objectives with significant contribution to the socio-economic & strategic sector. The supra-institutional projects that would help synergize the in-house capabilities include; drug development from natural resources for infectious, metabolic age related diseases & for reproductive health where in majority of the groups within the laboratory would participate to maximize the outputs. The inter agency programmes formulated in this sector are Pharmacogenomics and predictive therapy for complex diseases; and Validation of ayurvedic concepts of prakruti in metabolic disease predisposition, progression and drug response with special focus on metabolic disorders. To make drug discovery process efficient and globally acceptable, the creation of national facilities has been planned are for **:** establishment of dog facility for research and testing purposes ; functional MRI and MRS of rat and human; and high throughput fragment based screening using X-RAY/NMR on proteins from pathogenic sources and rational inhibitor optimization, world class drug research institute

SUPRA-INSTITUTIONAL PROGRAMMES

3.2.10.1 New drug development program for parasitic diseases and microbial infections (CDRI)

Tropical parasitic diseases such as malaria, leishmaniasis, and filariasis represent still a large health risk for a majority of the world's population. These diseases cause over 3 million deaths per year. The high number of disease cases is substantial cause of impediment for the economic development of the countries and the people concerned. The available drugs for treatment have some important disadvantages in terms of reduced availability and high price, strong side effects, long treatment, drug resistance development etc. as in case of malaria, the major factor contributing to the continued prevalence of the disease is the emergence of drug resistant strains therefore poses unprecedented challenges like the development of new safe and fast acting antimalarials to control the spread of multi-drug resistant *P. falciparum.* Leishmaniasis and Filariasis are endemic to India and a few other developing countries only and therefore require S&T solutions from indigenous sources due to lack of interest of pharma multinationals due to low volumes of drugs required for these diseases.

Mycobacterium tuberculosis, the etiologic agent of tuberculosis, is responsible for more deaths each year than any other single pathogen and is considered a major global threat. The problem can be attributed to several factors such as emergence of multi-drug resistant tubercule bacilli, inability to diagnose the disease early and compromise of immune mechanism in HIV-infected individuals. Moreover, no new drug has been added for treatment of TB in last 40 years, except for certain fluoroquinolones, which also have limitations due to rapid appearance of drug resistance. Newer and more effective interventions against TB could be achieved by studying the biology of the pathogen, particularly the biology of dormant / latent microbe so as to identify targets against which drugs could be developed

Research focus

Design, synthesis/isolation from natural sources and development of new therapeutic agents for Malaria, Filariasis, Leishmaniasis and Tuberculosis; development of new *in vitro*/high throughput and *in vivo* assays; basic biochemical, molecular and immunological studies for characterization of virulence and drug resistance genes and novel drug targets of diagnostic and therapeutic potential.

Envisaged outputs/outcomes

- Development of identified leads: i) Compound 97/78, antimalarial – Collaborative-cum-licensing agreement with IPCA Labs, Mumbai and ii) Compound 99/411, antimalarial – Completion of pre-clinical, pharmacokinetics, delivery systems and regulatory toxicity in monkey. Initiation of clinical trials if found safe.Creation of lead molecule pipeline and optimization of 'hits' identified against Tuberculosis and Cancer from HTS screening and their pre-clinical development .Characterization of mechanism of drug resistance in malaria parasite and in clinical isolates from Leishmania patients .Development of drug combinations of CDRI compounds with standard antimalarials to enhance efficacy and reduce drug resistance.Establishment of mechanism based *in vitro / in vivo* screening models and Characterization and validation of novel drug targets would be done.

3.2.10.2 New drug development programme for reproductive health and life-style diseases (CDRI)

The life-style and social culture is drastically changing all over the world and India is no exception. Competitiveness and desire of fast success in life has resulted in mental stress, unorganized daily routine and change in dietary habits from regular meal to fast food. Insecurity and lonliness leads to behavioural disorders which get complicated with development of neurological diseases associated with aging. High fat diet leads to dyslipidemia and obesity, which are major risk factors for hypertension and diabetes mellitus. Recently, hypercholestraemia has been linked with dementia disorders and stroke. Stress may also result in gastric ulcer, hypertension, diabetes mellitus and behavioural disorders like depression, anxiety and memory impairment. Working for hours in closed office deprive exposure to sun that may culminate in later ages into osteoporosis.

Osteoporosis accompanying menopause and other estrogen deficiency states represents major cause of morbidity and mortality in women world-over. The number of osteoporotic fracture worldwide by the year 2025 are expected to be ~2.78 million in women and ~1.16 millions in men, being most apparent in Asia. The available antiresorptive therapies for the management of estrogen deficiency osteoporosis are either not totally devoid of health hazards or are unacceptable due to their parenteral route of administration or high cost. Thus there is an urgent need to develop safe and effective anti-resorbing as well as osteogenic agents for human use and welfare.

Benign Prostate hyperplasia, a common disorder in aging males is characterized by progressive enlargement of prostate gland leading to urinary tract problems. The existing methods for its management are either surgery or associated with undesirable side effects. It is proposed to undertake development of novel, non-invasive and safe therapeutic approaches for its management.

Research focus

Design, synthesis/isolation from natural sources and development of new products/therapeutic agents for female and male contraception, breast cancer, benign prostatic hyperplasia, osteoporosis, stroke, thrombosis, dyslipidemia, stress, gastric ulcer & dementia; development of new *in vitro*/high throughput and *in vivo* assays; elucidation of mechanism of action of promising agents and basic studies for understanding crucial events to provide new leads having diagnostic or therapeutic potential.

Envisaged outputs/outcomes

Completion of Phase III clinical trials of the Compound 80/574, lipid lowering (licensed to Cadila Pharmaceuticals) .Development of identified leads: i) Compound 99/373, antiosteoporosis - ii) Compounds S-002-853 and 857, antihyperglycemic and antidyslipidmic - iii) NP –1, osteogenic; iv) CDR-134F194 and CDR-267F018, antihyperglycemic and antidyslipidemic.Completion of studies on molecular mechanism, pharmacokinetics, delivery systems and regulatory toxicity in monkey. Initiation of clinical trials if found safe. Creation of lead molecule pipeline and optimization of 'hits' against Thrombosis, Dyslipidemic and Memory enhancement and their pre-clinical development. Establishment of mechanism based *in vitro / in vivo* screening models for Cancer breast, Benign prostatic hyperplasia and Thrombosis

3.2.10.3 Development of novel target based anticancer therapeutics (RRL-Jammu)

Cancer is the second leading cause of death next to cardiovascular diseases. After the sequence of human genome established, it is estimated that more than 300 genes (1%) are mutated in cancer cell. This results in the cancer cell to grow amok. Programmed cell death (apoptosis), which is important to maintain number of cells is deregulated in most cancer cells where several core competent genes regulating cell death machinery are mutated. Currently, more than 50 % of anti-cancer drugs used in clinical practice are derived from plants, which continue to provide important treasure to develop newer anti-cancer drugs. In this endeavor, through the application of system/in silico biology approach, we aim to optimize the leads obtained so far, develop new chemistry around the new molecules to treat cancer encompassing chemo and immunotherapy.

Research focus

Develop and optimize the target based bioactive molecules for anticancer activity Develop chemistry around the leads obtained to create more effective ligands directed towards molecular targets of cancer cells. Structural designing of ligands using Insilco biology against molecular targets in cancer. To develop new cancer vaccines, synthetic and semi synthetic anticancer molecules based on hybrid structures, anti-oxidants, efflux pumps inhibitors, angiogenesis inhibitors, apoptosis inducers and tumor chemotherapeutics. To generate data base for herbal pro-apoptosis molecules.

Envisaged outputs/outcomes

- ➲ Development of newer herbals for cancer treatment/management. Data base of new molecules (IND) for anti-cancer therapeutics. Modulation of genes expression by novel chemotherapeutics in early diagnosis and the prognosis . Filing of two INDs.

3.2.10.4 Centre for chemical genomics (IICT)

In the post-genomic era of bio-informatics, biology and in chemistry taken together, have revolutionized the entire processing of drug development. In fact, it is emerging as a powerful and an efficient tool in development of drugs with much shorter time. The existing National Facility for Combinatorial Natural Products at IICT and the enviable strength, IICT possesses in chemistry have led IICT to propose this challenging and prestigious project on “Centre for Chemical Genomics for Drug Development”.

Research focus

To create a national multi-disciplinary “Center of Excellence” (the Center); to reengineer a translational and clinical research enterprise; and, to develop a "new Roadmap" for bench-side to bed-side, enabling India to leap-frog the West and lead, manage and control the healthcare product and service business around the globe. The Center will serve as a national resource for knowledge and wisdom, as well as develop and commercialize Life Science and healthcare products and services. Further, the Center will endeavor to foster and nurture an entrepreneurial Eco-system to create wealth. Most importantly, the Center will devise a new and sustainable business model with a dual pricing structure, charging market prices for the wealthy and drastically reduced prices for the impoverished and destitute

Envisaged outputs/outcomes

- ➲ This initiative addresses the inadequacies and enhancement of current methodologies and processes associated with launching a candidate drug molecule into the market. The initiative includes: (1) the tools and processes for target selection and validation; (2) drug design development and validation; (3) automation technologies for efficient high throughput screening; (4) predictive screens on acquiring good ADME/Tox data earlier in the discovery/pre-clinical research process; and, (5) accurate and efficient tools and methodologies for patient selection and monitoring leading to improve out come of clinical trials.
- ➲ Development of New pathways to drug discovery through Target Discovery and Validation, identify the existing and new Biological Pathways, Drug Design, development & Validation and Nanotechnology and Drug Discovery Vehicles
- ➲ For re-engineering the clinical research enterprise, some avenues by which this may be achieved are: (1) the use of bio-markers, either as surrogate endpoints or as companion diagnostics, to facilitate subject recruitment and therapy selection in clinical trials, guide dose and regimen decisions, as well as to streamline the regulatory approval process; (2) stratification of study subjects during clinical trial design, into target populations to better elucidate the safety and benefits of the drug candidate for humans; and, (3) developing clinical research networks to rapidly conduct high quality clinical trials and research. Once available, these clinical research networks can rapidly and efficiently answer specific safety queries using a standardized procedure available data generated by such groups.

NETWORK PROJECTS

3.2.10.5 Plants and microbes as bioreactors for the production of pharmaceutically and industrially valuable proteins (*NBRI.* NCL, IMT, NIO,CCMB,IHBT)

Proteins are widely used as diagnostic reagents, vaccines, drugs and in a variety of industrial applications. This has created a high demand for the production of recombinant proteins on industrial scale. Commercial protein production has traditionally relied on microbial fermentation and mammalian cell lines. However, these systems have limitations related to the complexity of post translational protein modification, cost, scalability and bio-safety. This has prompted researchers to search for alternate production technologies for recombinant proteins. Plants as bioreactors have emerged as one of the highly promising alternative production platforms, especially for complex proteins. The bacterial and yeast systems have been in use for simple proteins but yet have major opportunities for improvement and generation of IPR.

Research focus

Technologies will be developed for the development of: novel promoters for high level and tissue specific expression in leave (tobacco) and seeds (ground nut), indigenous vectors for nuclear and chloroplast transformation in plants, an yeast expression system based on alcohol oxidase promoter. Genetic engineering of plants and yeasts for high level expression of pharmaceutically and industrially valuable proteins like: Rabies glycoprotein, alpha-1-antitrypsin, clot specific streptokinase, phytase, laccase, dihydro flavone reductase, therapeutic and diagnostic antibody. Development of process technologies for scale up and purification of recombinant proteins.

Envisaged outputs/outcomes

- Expression vectors for yeast and plants and technologies for expression of genes and use as bioreactors. Genes for high value therapeutic and industrial proteins. Comparative assessment of plants, yeast and bacteria for high level expression of therapeutically and industrially important proteins. Transgenic tobacco, groundnut, chickpea, rice, potato, bamboo and yeasts expressing therapeutically and industrially important target proteins.Commercialisable plant and microbial bioreactors for preparing rabies glycoprotein, clot specific streptokinase and alpha-1-antitrypsin proteins. 5-7 Research publications and 2-3 patents

3.2.10.6 Diabetes Mellitus – New drug discovery r&d, molecular mechanisms and genetic factors (*CDRI*, IGIB, CCMB, RRL-Jm., IICB)

Diabetes mellitus Type 2 (T2DM) is a heterogeneous, polygenic disease with a complex inheritance pattern and is caused by genetic predisposition and environmental factors. Chronic hyperglycemia is often associated with essential hypertension, obesity and dyslipidemia in a complex metabolic syndrome leading to severe vascular complications. The precise biochemical defects in these conditions are still unknown but they almost certainly include impairments of both insulin secretion and action. According to world health organization (WHO) projections, the 30 to 33 million diabetics in India will go up to 40 million by 2010 and 74 million by 2025.

Given the alarming scenario in India as well as globally, it is of utmost essentiality to study each and every component of the disease holistically for better comprehension and generate a strong knowledgebase for possible preventive and therapeutic interventions. Although number of new classes of therapeutic agents are currently in use for diabetes management but none of these are optimal and none alone can achieve satisfactory glycemic control that can be sustained thereby stressing the requirement for development of more safe, simple and effective agents. A strong inter-laboratory collaboration is required to seriously venture into this area for an extensive understanding of the etiology, pathophysiology and molecular mechanisms.

Research focus

Design, synthesis/isolation from natural sources and development of new therapeutic agents for type ii *diabetes mellitus*; development of new *in vitro*/ high throughput and *in vivo* assays; elucidation of mechanism of action of promising agents; genetic, epigenetic and proteomic basis of the disease and identification of biomarkers and mechanism of disease progression.

Envisaged outputs/outcomes

- Development of identified leads: i) Compounds S-002-853 and 857, and ii) Marine products CDR-134F194 and CDR-267F018, antihyperglycemic and antidyslipidemic - Completion of studies on molecular mechanism, pharmacokinetics, delivery systems and regulatory toxicity in monkey. Initiation of clinical trials if found safe. Creation of lead molecule pipeline and optimization of 'hits' and their pre-clinical development. Establishment of mechanism based *in vitro / in vivo* screening models. Identification of biomarkers for T2DM and mechanism of disease progression. Creation of Biobank for T2DM plasma and DNA samples.Financial Resource Requirement

3.2.10.7. Cell and tissue engineering of animal and human cells (*CCMB*, IICB, ITRC, CLRI, CDRI, RRL-Tvm., CGCRI,IICT)

The field of cell and tissue engineering is growing rapidly- especially as a methodology for human applications for designing cell-based therapy for many chronic and acute human diseases for which no other remedy exists. This technology has the potential to provide more effective, safe and sustainable remedies for life-threatening and debilitating diseases.Therefor the basic and practical knowledge about isolation , characterization of animal and human tissue, culturing as well as preservation of stem cells is a must to develop cell based therapy for human beings for various diseases..

Research focus

Isolation and characterization of stem cells from different animal and human tissues such as skeletal muscle, human cornea, human in mouse embryos, human fetal liver, umbilical cord blood and bone marrow. Develop new methodologies for long term culture of stem cells in their undifferentiated form and for cryopreservation and transfer of human stem cells in human disease models developed in experimental animals. Develop new substrata scaffolds and other devises to support the culturing, transfer or maintenance of stem cells. Carry out basic research on the cell signalling pathways specifically in the nucleus and cytoplasm of stem cells to understand the basic biology of embryonic and adult stem cells.Develop RNAi strategies to control the differentiation of human stem cells and develop protocols for the transfer of in vitro expanded stem cells (autologous and heterologous) into humans with various diseases.

Envisaged outputs/outcomes

- Two facilities for preparation of cells for human cell therapy as per internationally certifiable standards and three animal disease models for the diseases like lieshmaniasis, myocardial infraction and liver disease would be developed.

3.2.10.8 Development of comprehensive *in silico* tool for cost effective clinical trial (*IGIB,* IMT, RRL-jm., CDRI, NCL)

Comparative genomics is central to the discovery of new drug targets and to design and aid cost effective clinical trials to alert the Pharmaceutical companies of potential failures prior to conducting field trials by recruiting human volunteers. Global initiatives in identification and characterization for functional entities within the human genome are primarily focused on the coding genome and it is proposed that this project be initiated from 2009 for five years. It is envisaged that the global (as well as IGIB) curation and annotation projects will near completion in the next few years. This project is strategically positioned for using this information effectively. Secondly, the in-house project on SNP discovery/validation in the tenth plan period has generated an unprecedented amount of data on genomic variation within the Indian population – analysis of this data is envisaged to be complete in the next one or two years. The current proposal will be able to harness such analytical data on the Indian population (specifically for the first two major objectives given above) effectively only if it is slated to begin in 2009. However, the ground work for this purpose is being laid out currently. Similarly, another major project on pharmacogenomics (proposed in the 11th five year plan) is expected to collate substantial data by 2009 to be of significant help in the current project. Taken together, the strategic timing of this project (2009 – 2014) is such that parallel projects initiated in CSIR and in-progress globally are in a position to feed-in to the major objectives in the current project. Information on putative regulatory regions (mostly proximal promoters) is likely to become available.

Research focus

Multi-dimensional computational simulation of drug metabolism in liver: An integrative biology approach. Comprehensive pathway modeling for development of therapeutic strategy for pathway based target than single protein target.*In vitro* model of *in vivo* toxicity: Known drugs with alternative protein binding.*In silico* modeling of peptide -based drugs for infectious diseases.High throughput protein-protein and protein-ligand interactions in multi dimensional environment simulating *in vivo* condition. Database creation, mining, analysis for toxicity and activity prediction for development of a comprehensive software for *in silico* clinical trial

Envisaged outputs/outcomes

- Development and commercialization of four software packages and provide Services to Pharma companies using the proprietary software.

3.2.10.9 Development of diagnostics and target-based molecular medicines against allergy, bronchial asthma and chronic obstructive pulmonary disease (*IICB*, IGIB, IICT, ITRC, CCMB, RRL-Jm.,)

Twelve lead molecules have been purified from herbal sources or synthesized against three key targets of bronchial asthma including phosphodiesterase E4 (PDE4). In addition to bronchial asthma, this enzyme is also involved in chronic obstructive pulmonary disease (COPD). The PDE4 inhibitors are likely to be effective against bronchial asthma and COPD. Two molecules are effective *in vivo* in mouse model of bronchial asthma. Toxicity studies indicate that these two molecules have wide therapeutic window. Pharmacokinetics, mutagenecity and other *in vivo* studies on these lead molecules need to be performed. Also, identified genetic polymorphism in a number of genes, risk/protective alleles, genotypes and haplotypes in the Indian population. Tremendous heterogeneity in asthma pathogenesis demands the identification of biomarkers for development of diagnostics.

Research focus

In vivo evaluation of lead molecules and combination of lead molecules for synergism in animal models. Toxicity, pharmacokinetics and bio-availability studies with the optimized lead molecules. Synthesis of NCEs based on a) SAR studies and b) the natural product scaffolds for identified targets. Application of X-ray crystallography and bioinformatics for lead optimization and synthesis of derivatives. Identification and validation of novel targets at the levels of genes and proteins. Development of diagnostic biomarkers using proteomics of sputum.

Envisaged outputs/outcomes

➲ Commercialization of optimized lead molecules.

3.2.10.10 Identification and validation of drug targets for selected pathogens (*CDRI,* IMT, CCMB, IGIB, RRl-Jm., CIMAP)

Identification and development of drug targets in pathogens, through the application of modern molecular biology techniques could be an insight for designing of new drugs. Further validation of a drug target offers one step ahead opportunity for the development of new target specific drugs against the pathogens. Target validation is to verify with the help of target specific assays that a target is primarily responsible for the therapeutic activity of a proven drug, or demonstrating the essential nature of a putative drug target in a parasite, and the capacity for selective inhibition of that target *in vivo*. The pathogens selected are *Mycobacterium tuberculosis*, *Plasmodium falciparum* and *Leishmania donovani,* the causal agents of tuberculosis, cerebral malaria and kala-azar, respectively. A number of drug targets for these pathogens have already been identified and among these the targets showing promising potential for drug development have been selected for further validation. Development of target specific assays and screening of available synthetic / natural chemical libraries for identification of novel drugs is envisaged. Identification of newer drug targets in these pathogens is also an intrinsic part of the proposal.

Research focus

Identification of pathogen-specific, differentially expressed proteins of M*ycobacterium tuberculosis*, *Plasmodium falciparum*, *Leishmania donovani*, and their validation as drug targets. Validation of a number of identified drug targets for these pathogens generated from the X plan programme SMM003. Development of target-specific assays and screening of available synthetic/ natural chemical libraries.

Envisaged outputs/outcomes

➲ Mycobacterium tuberculosis

Study of essential enzymes selected viz. Protein kinase F, nucleoside diphosphate kinase, tyrosine phosphatase, peptidyl tRNA hydrolase, chorismate mutase, NAD dependent DNA ligase, polypeptide deformylase, and alpha 1-4 glucan branching enzyme and validation of the above putative targets and delineation of their role in specific pathways. Development of target-specific new screening systems.

➲ Plasmodium falciparum

Study of new drug targets in the context of apicoplast DNA replication and translation and functional analysis of proteins expressed on the infected erythrocytes identified using 'immunoproteomic' approach.

➲ Leishmania donovani

Study of selected essential enzymes adenosine kinase, DNA topoisomerases I and II, and dipeptidylcarboxipeptidase as well as selected virulence factors such as mitochondrial tRNA-binding protein, laminin binding protein, actin and actin-binding proteins.

3.2.10.11 Validation of identified models and development of new alternative models for evaluation of new drug entities (*CDRI*, ITRC, IGIB, IMT,CFRI)

Use of experimental animals in drug discovery, development and toxicity evaluation is inevitable. However, the number of animals used in such studies could be reduced by developing alternative methods and models. This approach would not only be helpful in reducing animal use in experiments but also facilitate the understanding the mechanism of action of the new drug entities. The project is intended to develop alternative models using bacteria, algae, plant tissues, animal cell lines, yeast, and drosophila for all stages of screening as well as toxicity evaluation. *In vivo* and *in vitro* models on genotoxicity, neurotoxicity, immunotoxicity and hepatotoxicity essential for regulatory toxicity will be established and development of transgenic cell lines with drug target gene would also be attempted.

Research focus

Validation of the established models (Drosophila, yeast and cell based) developed in X plan period and their use in drug evaluation. Development of new alternative models (bacterial, yeast, cell based, Drosophila and rodent) and methods. Application of the newer technologies like *in silico* methods, microarray and RNAi for evaluation of New Chemical Entities (NCEs) to refine the experiments in drug evaluation and toxicity studies to reduce number of animals. Understanding the mechanism of action of NCEs. Establishing the available assays especially in toxicology (Internationally accepted models) at different laboratories to fulfill the requirements of Drug Development.

Envisaged outputs/outcomes

- Development and standardization of new alternative models using mycobacterium, yeast, drosophila and cell based models for drug screening and toxicity evaluation. Screening of many NCEs for different diseases using these models. New active molecules are expected to be identified.Reduction and refinement of animal use in biomedical research will be achieved

3.2.10.12 Nanomaterials and nanodevices for application in health and disease (*CCMB*, CSIO, IICT, CEERI, RRL-Tvm., RRL-Bhub., CDRI, NML, IGIB, ITRC, CECRI, RRL-Bhopal, IICB, CMERI, CSMCRI, CGCRI, CLRI, NCL, IHBT, NIO)

Development of nanodevices and nanomaterial for applications in health science has tremendous potential since it offers fundamentally different approach(s) to treat and prevent diseases. Self-assembly, the hallmark of nanomaterials, is remarkably used in biology. Multiple functionalization of nanostructures allows development of complex therapeutic vehicles with specificities and efficiencies. Biointerfacing of nanodevices such as cantilevers, semi-conductor devices etc. would lead to fabrication of specific and sensitive detectors of utility in health and environment.

Research focus

Integration of expertise to develop nanoparticles for nucleric acid/ drug delivery and contrasting agents in vivo and in vitro .Engineering of surfaces for efficient prosthetics.Nanodevices, cantilever/ Lab-on-Chips etc., for detection of clinical analytes and pathogens.Profiling nanomaterial – biosystem interactions for safety evaluation

Envisaged outputs/outcomes

- Nanomaterials with programmable delivery of therapeutic agents such as antibodies, RNAi, drugs, DNA and protein. Nanodevices for detection of clinical analytes and viruses using cantilevers, semi-conductor devices and microfluidics. Nanomaterial interaction with biosystems to evaluate biosafety at a cell and organism level.

3.2.10.13 Comparative genomics and biology of non-coding RNA in the human genome (*IGIB*, IICB, IICT,CDRI,NCL)

Conservation and variation are counter balancing forces that shape the genome. In the protein coding regions, conserved regions, including peptide stretches that remain invariant from bacteria to human establish the fundamental relation between structure and function. Conservation in the non-coding region, indicates their functional role and recently the widespread regulatory reach of these molecules have come to light following identification of a large number of non coding RNA molecules which can modulate the expression of protein coding genes. Besides the non-coding regions of protein coding transcripts, entire non-coding transcripts may act as a source of small RNA molecules, prepared by specific processing steps. The sheer numbers of miRNAs and their potential targets have led to the suggestion that, like transcription factors, the expression patterns of miRNA may establish tissue specific codes and determine, cells growth, development and differentiation.

Increasingly it is becoming clear that in addition to translational inhibition, target cleavage, destabilization by deadenylation and probably even silencing by sequestration into sub-cellular sites or guiding epigenetic modification may all be used by miRNAs to down regulate target gene expression.

The ever growing reports of miRNA in disease has opened up numerous therapeutic possibilities. But development of these applications require a close network of Chemists and Biologists working together to develop (1) detection technology (2) agents for improving the stability of anti-miRNA molecules (3) technology for packaging and targeted delivery of small RNA. However, the conventional barriers between disciplines remain challenges to interdisciplinary approaches.

Research focus

➲ Fundamental interest (Biology):

An integrated approach towards understanding the role of conserved/non conserved non coding RNAs in human genome.Delineation of physicochemical principles governing small RNA-mRNA interaction.Mapping the non-coding RNA potential of the genome.Correlating transcriptome, non-coding RNA and the proteome.Role of variation in non-coding RNA.miRNA in Disease progression and susceptibility.Networks modulated by miRNA mediated regulation

➲ Applied interest (Biotechnology)

Development of miRNA based diagnostics for cancer. Development of miRNA as a prognostic marker for cancer and viral disease susceptibility.Development of modified Nucleic Acids to enhance miRNA –target hybridization. Development of sugar based small molecules for RNA recognition.Transfection agents for small RNA packaging and delivery.

Envisaged outputs/outcomes

➲ Development of disease progression biomarkers for various diseases like cancer, metabolic diseases, fatal human and animal viral infections .

3.2.10.14 Discovery and preclinical studies of new bioactive molecules (natural and semi- synthetic) & traditional preparations (*CSIR Hq,* RRL-Jm., CDRI, IICB,IICT, ITRC, RRL-Tvm., RRL-Bhopal, RRL-Bhub., IHBT, NCL, CFTRI, CBRI, NBRI, CIMAP, IMT, CCRAS, CCRUM, AVS-Trivandrum)

The Draft National Pharmaceutical Policy, 2006 has focused on Research and Development, Process Development, Drug Discovery, Drug Development and clinical trials incentives.

The Council of Scientific & Industrial Research has been an important player in developing new therapeutics. CSIR mounted the networked programme (2003-07) entitled "Network Project "Discovery, Development & Commercialisation of New Bioactives & Traditional Preparations" (COR-23) where around twenty CSIR Institute were networked. All the discoveries were based on biodiversity of India in terms of her plant and microbial wealth as well as prior experience available with the traditional systems of medicine for which collaborations were established with CCRUM, CCRAS and Arya Vaidya sala, Kotkal.

The plan of study included Collection of plant material, preparation of extracts, bioevaluation (in vitro and in vivo) for various diseases (Malaria, Filaria, Tuberculosis, Leishmania, Dementia, Hypertension, Inflammation, Diabetes, Bacterial and fungal infections, Immunomodulation, Hepatic disorders, Gastric Ulcer, Cancer, Antioxidant activity, Depression, Anxiety and Parkinson's disease) activity guided fractionation to obtain a lead single molecule or decision to develop a herbal lead, toxicological investigations, optimization of structure or optimization of the composition of the herbal lead.

Research focus

To carry out all the required preclinical studies for filing IND for specific diseases where the demands are still unmet to develop.Single molecule based therapeutic agents of interest to India as well as to the rest of the world. Herbals as therapeutics based on single or multiple herbs. Revalidation and optimization of the promising active samples already identified to develop INDs. To carryout necessary preclinical studies including safety, proof of efficacy etc. Collection, extraction and bioevaluation of new plants samples to identify new leads.

Envisaged outputs/outcomes

➲ Development of newer single molecules/herbal therapeutics for different diseases.Database of activity profiles of Indian plants, microbes and fungi for various diseases. Filing of six INDs (Herbal-4 + Single molecules-2)

INTER AGENCY PROGRAMMES

3.2.10.15 Pharmacogenomics and predictive therapy for complex diseases: genomic basis of variability in drug response: providing molecular rationale for usage of low cost drugs for public health care system. *e.g.* epilepsy, mental disorders etc.(*IGIB*, IHBAMS-Delhi, NIMHANS-Bangalore, MAHE-Manipal, VIMHANS-Delhi, AIIMS, CDRI)

Patients display significant differences in response to therapeutic agents, which may be caused by a variety of factors like genetic constitution. Pharmacogenomics of drugs prescribed for common diseases such as epilepsy, mental disorders etc. is needed for individual specific therapy (personalized medicine) as these diseases have emerged as a major public health problem in recent years. Recognizing the growing importance of a pharmacogenomics based approach to facilitate the development and delivery of safe and effective medicines we propose to develop a pharmacogenomics SNP database of drug response genes for such common diseases in the Indian population, which will provide the molecular rationale for usage of low cost drugs for public health care. Pharmacogenomic aspects of drugs in Indian population and will be a deciding factor for the choice of low cost drugs for the patients coming from underprivileged class of our society.

Research focus

Identification of predictive markers for drug efficacy/side effects to low cost drugs through genotype and drug responsive phenotype profiles. Identification of novel markers/haplotypes predicting responsiveness to drug therapy. Validation and estimation of frequency and of function variations in drug responsive genes in reference Indian populations. Development of a genotype-drug response phenotype database. Development of customized chips for drug response studies

Envisaged outputs/outcomes

- This pharmacogenomic approach is expected to develop personalized medicine where, for example, older drugs can be revived for some and the newer ones can be predicted for their therapeutic efficacy and side effect in others.
- Develop drug specific SNP chip with public private partnership for personalized predictive therapy (medicine) for complex diseases such as epilepsy, schizophrenia etc in Indian population.
- Development of database for Pharmacogenomics in India- Large genomic data, molecular and cellular phenotype data, and clinical phenotype data will be organized to know the relationships between genes and drugs.
- Reduction in costs/time lines associated with clinical trials as well as to improvements in the efficacy of therapeutic compounds

3.2.10.16 Validation of ayurvedic concepts of prakruti in metabolic disease predisposition, progression and drug response with special focus on metabolic disorders (*NBRI,* IGIB, CDRI, AYUSH)

The Indian traditional system of Ayurvedic medicine has its basic tenet as predictive medicine where prevention, diagnosis as well therapeutic regime is personalized and the susceptibility or prognosis for a disease is determined by an individual's phenotypic constitution. According to Ayurveda all of us are born with a specific basic constitution which is referred to as "Prakruti". This constitution can be broadly classified into seven types. Response to external environment, suitability or otherwise towards different types of food, predisposition towards different diseases as well as their prognosis and management is unique to a constitution, which is decided on the basis of certain phenotypic criteria. In 10 to 20 years from now, it is envisaged that the focus of medicine would shift from treating existing diseases, typically late in their progression, to preventing disease before it sets in. Further into the future, it is expected that medicine would become personalized, with therapies that match patients' genetic makeup. The final outcome is expected to be predictive medicine wherein each of us will have to be treated differently, based on the variability in our genetic make up. Complementing knowledge of prakruti with the available human genome sequence as well as variability information and development of high throughput expression measurement methodologies might help us envision predictive medicine in future.

Research focus

To identify biological pathways/ candidate genes over-represented in individuals of specific prakruti and to correlate epigenetic modification with Prakruti.To cross validate informative markers in cohorts drawn from different subpopulations.To correlate based on Prakruti, predisposition and progression for metabolic disorders.To study the effect of Prakruti specific drugs for e.g anti-hyperglycemic drugs in model systems and identification of candidate pathways. To elucidate molecular mechanism of Dosha specific drug action .To elucidate molecular pathways underlying the development and progression of dosha specific diseases.

Envisaged outputs/outcomes

- Parameters/biomarkers for classifying individuals as per the concepts of Ayurveda. Scientific validation of the concept. Metabolic & genomic markers for prakruti & its relationship with disease pre- disposition. Scientifically validated plant drugs for metabolic disorder e.g. diabetes and prakruti related drug response. Disease progression & drug response data on plant drugs for metabolic disorders in different Prakruti. The study would provide scientific basis to the system of Ayurveda and establish ancient Indian wisdom on globally competitive platform

NATIONAL FACILITLIES

3.2.10.17 A national biosafety level 4 (BSL4) facility for infectious diseases caused by dangerous microorganisms (CCMB)

Infectious diseases are among the major problems confronting humanity today. Microbes devastated populations and destroyed empires throughout history. But their limiting factors were that people did not travel long distances and most had not settled into large cities. Today the situation is different. Infectious diseases are breaking the international barriers and affecting people globally. In the recent past, new infectious organisms such as SARS virus have appeared to threaten human population; this virus infected 8,098 people world-wide and killed 774 persons. There is now growing concern about the outbreak of Avian-flu caused by viral infection, which infected more than 110 people in Asia and killed at least 60. The World Health Organization (WHO) had already sent alarming signals to countries to be prepared in the event of such a disease spreading to humans. WHO has also reported that infectious diseases are still a major cause of death globally, of which up to 50% occur in the developing world.

The recent outbreak of Japanese Encephalitis (JE) in UP, Bihar and Nepal was yet another example where 3,551 children were affected resulting in the death of more than 764 lives. This incident has exposed our inability to prevent and control infectious disease of this magnitude. This has led to the importance and necessity of having a Biological Safety Level 4 (BSL4) facility, wherein biohazardous microorganisms can be safely handled. CCMB has already initiated the process of setting up this world-class facility with funding from CSIR and DST. Until such time the BSL4 facility is set up, a prefabricated BSL3 facility would become operational. This would enable scientists to carry out work on organisms, such as SARS and Avian-flu virus and for scientific evaluation of sudden outbreaks of diseases, like the Nipah virus, West Nile virus and other agents of unknown etiology. This would also serve in housing animal models of such highly infectious organisms, so that new drug trials can be carried out on them to facilitate drug and vaccine development by research organizations as well as pharmaceutical and biotech industries.

Aim of the facility

To carryout high quality basic R&D work on risk level 4 microorganisms and drug resistant forms of HIV and TB .Establishing Collaborations with Pharmaceutical Companies and International Research Institutions and increasing public awareness about infectious diseases. Development of new therapies and vaccines for diseases of national relevance. Study the pathogenesis and mechanisms of infection.

Envisaged outputs/outcomes

- Once the BSL4 Facility is established, it will accelerate high quality basic R&D work on risk level 4 microorganisms and drug resistant forms of HIV and TB. The facility would help Pharmaceutical and Biotech Companies to develop cost effective drugs and vaccines affordable by the people.Provide training to researchers from academic and research and to study the pathogenesis and mechanisms of infection.Diagnostic kits and reagents for early detection of disease will be developed.

3.2.10.18 Establishment of dog facility for research and testing purposes (CDRI)

The development of pharmaceutical compounds, vaccines and herbal products essentially requires use of one rodent and one non-rodent animal species as experimental model for testing and evaluation of efficacy, safety and toxicity responses of these compounds according to norms laid-down by the regulatory authorities. Of these animal models, the 'dog' contributes significantly as an alternative to higher vertebrate species, especially the non-human primates (monkeys). Though some pharmaceutical companies have initiated studies with dogs after establishing kennel facility but are unable to supply to other research institutions. Moreover, there is no recognized center in India that can provide dogs of defined status to meet the requirements of regulatory studies. Therefore, there is an emergent need of developing a national level resource for production of pure breed of this species. This can be achieved through establishing a breeding set-up of beagle dog, as it is easy to maintain, breed and handle this species under captive laboratory conditions. The facility would not only provide animals for in-house purpose but, strengthen the entire pharma industry setting up new R&D centers through contract research and generate globally acceptable knowledge/information.

Aim of the facility

The aim is to set up a facility for breeding and maintenance of beagle dogs as this is an internationally accepted higher animal species for undertaking regulatory toxicity and pharmacology of candidate drugs/vaccines and herbal products. To fulfill legislative requirements of drug testing as per schedule 'Y' of drug & cosmetic act and CPCSEA using in-bred animals.

Envisaged outputs/outcomes

- Maintenance and breeding of beagle dogs for in-house higher animal regulatory studies.Supply to other R&D organizations and Pharma industry.Attract contractual research and generate internationally acceptable data

3.2.10.19 Magnetic resonance imaging (MRI) and magnetic resonance spectroscopy (MRS) facility for investigation of molecular and cellular processes in rat and human (CCMB)

Accurate diagnosis and study of prognosis during treatment of a disease through non invasive techniques and tools such as MRI & MRS finds an important place in the area of healthcare. MRI is a diagnostic procedure that produces detailed images of organs and structures within the body. In many cases, MRI provides information that cannot be seen on an X-ray, ultrasound, or computed tomography (CT) scan. Magnetic resonance spectroscopy (MRS) is another noninvasive procedure used to assess chemical abnormalities in body tissues such as the brain. MRS can be used to assess complex disorders such as HIV infection of the brain, stroke, head injury, coma, Alzheimer's disease, tumors, and multiple sclerosis. Magnetic resonance imaging (MRI) has helped revolutionize the practice of medicine over the past two decades by providing detailed pictures of the interior of the human body, in the process improving the diagnosis of disease and the planning of surgery. MR spectroscopy has evolved into a mature technology that is enhancing basic studies of phenotyping, drug discovery, pathology, and toxicology studies.MRI & MRS facilities are proposed to be established for study of molecular and metabolic basis of some selected diseases.

Aim of the facility

Setup functional MRI and *in vivo* MRS program to study disease in human and rodent model. To understand metabolic basis of neurological disorders (Alzheimer, Parkinson, epilepsy, depression etc.) in mice and rats. To study sensory and cognitive function, the level of cerebral metabolites and neurotransmission energetic with the progression of disease. Translate these studies to various diseases in human.

Envisaged outputs/outcomes

➲ The creation of this facility will be strategically important for providing infrastructure for studying diseases in non-invasive manner. The proposed facility will be useful in the management of public health in relation with diagnosis and follow up of disease with time during treatment. These studies are expected to provide critically needed data on the effects of various neurological disorders on sensory and cognitive function, neurotransmitter amino acid synthesis and glucose oxidation. The outcome of these studies will be beneficial in understanding as well as in identifying the defects in metabolic pathways in disease, therefore will be an important step for the drug design for the cure of these diseases.

3.2.10.20 High throughput fragment based screening using X-RAY/NMR on proteins from pathogenic sources and rational inhibitor optimization (CDRI)

Fragment based drug discovery involves identification of small molecular fragments (Mol. Wt <300 Da) which by themselves exhibit specific and naturally weak affinity for a particular protein drug target but can be designed into high affinity molecules with diverse scaffolds using medicinal chemistry and structure-activity relationship approaches. The value of fragment-based screening is greatly dependent on finding 'useful starting fragments' and modern technological developments like High throughput X-ray and NMR have not only enabled experimental identification of useful starting fragments but also provide extensive insight into protein-ligand interactions even when protein crystals are not available.

Aim of the facility

Creation /construction of fragment libraries *(in vitro & in silico)* for use by X-ray and NMR as also acquisition of commercial libraries for use. Structural elucidation of proteins and complexes by X-ray / NMR. Medicinal chemistry /synthetic chemistry/ combinatorial approaches involving CDRI to synthesize molecules based on results. Development/identification of suitable assays. Actual *in vitro / in vivo* testing and assays of synthesized molecules. Optimization of inhibitory potency by X–ray / NMR based on feedback & rational strategies using virtual screening approaches based on specific libraries designed around useful parent fragments.

Envisaged outputs/outcomes

- Identification and optimization of Anti-tubercular and multi-drug resistant complicated malaria candidate lead of leads. Strong library of backup compounds as potential anti-tubercular and anti-malarials as well as would be would be developed. Structural elucidation of important proteins/complexes from pathogenic sources.

Total Plan budgetary requirement projected for the Sector is Rs. 927 crore

3.2.11 HOUSING, ROAD & CONSTRUCTION

Construction forms a major part of development plan of developing countries including India. The Government of India has set major goals to be achieved by 2020 which requires greater thrust in all sectors of the economy including housing, roads, railways, power plants, transport and communication. There will be greater demand for the construction industry to meet the challenges to build economical and safe structures in shorter time. With the recent advancement of knowledge in Structural Engineering, the various codes of practices for analysis, design and construction will need to be revised continuously to enable more rational design of structures and their construction. Recent developments in high performance concrete, self compacting concrete, use of industrial wastes, high strength structural steels and cold formed steels have to be put into practice so that structures with greater strength and durability can be built.

Damages occur in structures due to various reasons including corrosion, fire, overloading/dynamic loading and ageing. Structures are also subjected to various types of damages due to natural and man-made disasters. Methodologies have to be developed for quantification of damage/deterioration of structures and assessment of life of structures with various type and degree of damage. It is also necessary to study appropriate damage control measures under extreme loading conditions like cyclone and earthquake. Studies are also required for quantification of blast loading on special structures and design methodologies including use of lased-reinforced concrete. Several new materials like FRP bars and FRP mats have recently been introduced which can be used for retrofitting of damaged structures. The efficiency of various retrofitting techniques has to be studied and guidelines have to be prepared for using them in damaged structures.

With large demand for infrastructure development, management of special structures and life enhancement is considered to be very important. Special tools have to be developed for management of special structures including reliability based inspection schedules.

Railway and road bridges form an important part of transport system. Many of them are old and designed for much less traffic than the present traffic loads. There is an urgent need for these bridges to be rated for their strength and stiffness. This requires proper methodology for estimating the strength and stiffness of bridge decks including field tests to estimate various loadings and forces, track-bridge interaction studies etc. Strengthening methods including external prestressing technique have to be studied.

The Indian subcontinent faces threat from many natural disasters. Earthquakes, cyclones and tsunami are common amongst them. There are also other disasters due to blast etc. There is need to estimate the loads and response of structures for engineering of structures against natural and other disasters. It is also necessary to study various damage control measures for structures. Since many areas are vulnerable for more than one type of disaster, proper methods have to be established for multi-hazard prone areas for which there are no guidelines at present.

Country is witnessing huge investments in road construction sector to the tune of Rs. 2.2 Lakh Crore. With such an investment, the quantum of work involved is tremendous and the responsibility of the profession to maintain it becomes all the more important. CRRI is procuring Accelerated Pavement Testing Facility (APTF) under its Tenth Five Year Plan which is expected to be fully commissioned by March 2009. The facility costing Rs. 13 crore has the capability to determine the performance of a section within 4-6 months as compared to 5-10 years in the filed conditions. It will be utilized to study appropriateness of our existing pavement design and specifications and for studying the suitability of new materials, techniques and technologies concerning new design methods and specifications etc.

The traffic situation in most of the metropolitan cities is getting worse due to exponential increase in number of vehicles. The solution lies only with the use of Intelligent Transport System (ITS) in traffic management and other related aspects. Based on the experiences gained from the pilot study carried out by CRRI under its Tenth Plan, it is felt prudent to take forward the use of ITS by developing a complete set of solution for a metropolitan city. Noise and air pollution are expected to be a cause of concern in near future as well which can be addressed through ITS solution.

The thrust areas for this sector in the new plan would be on development of new capabilities for the following: Maintenance & life enhancement of the special structures, health assessment of road & railway bridges at various places across the country and development of (i) new material & construction technologies, (ii) management system for roads, (iii) energy efficient buildings, (iv) structures capable of combating natural & man made hazards (v) coating to avoid corrosion in Oil and Gas structural facilities and Traffic and (vi) traffic management centre and application of Intelligent Transport System for Delhi Region.

SUPRA-INSTITUTIONAL PROGRAMMES

3.2.11.1 Management tools for maintenance, scheduling and life enhancement of special structures (SERC)

Most of the critical civil engineering structures are constructed using steel and concrete as structural material. The constructed structures deteriorate with time as a result of aging of materials, overloading, unfavourable environment conditions etc. Many infrastructural systems presently in operation in India are in need of rehabilitation through major repairs. In order to take a decision about the possible repair measures to rehabilitate the distressed structures, it is necessary to identify various damage mechanisms and reliably estimate the existing level of distress. Assessing the condition of 'in-service' concrete structures is fairly a difficult task. The data obtained from on-site measurement is useful for condition assessment and enabling timely retrofitting measures.

The premature deterioration of many of the reinforced/prestressed concrete bridges has necessitated the need for continual structural health monitoring to determine the existence, location and extent (or degree) of damage, if any, in the structure. Also, the remaining life assessment and damage modelling of structures requires the identification of time of occurrence of the damage event. It is proposed to develop methodologies for identification of time of occurrence of damaging event and for cost-optimised risk-based maintenance planning of structures based on continuous health monitoring data.

Many of the tasks related to performance evaluation and upgradation of existing structures are repetitive in nature. It is, hence, essential to develop management tools that entail substantial savings in time and cost and help the authorities to maintain and preserve the existing infrastructure in the most scientific manner. It is also essential to formulate precise and logical guidelines to have realistic estimates of remaining service life and residual strength of existing structures. The proposed studies will result in better decision making to maintain, preserve and enhance the costly and essential infrastructure of our country.

Research focus

The standard procedures and methodologies for quantification of damage/deterioration of special structures with age and exposure to extreme events would be developed so as to develop reliability based inspection/maintenance schedule for health monitoring of structures and to suggest retrofitting techniques for various types of damages and prepare a compendium. The models for assessing the life of structures with various types of damages before and after retrofitting would also be developed.

Envisaged outputs/outcomes

➲ The knowledge generated from the project is expected to result in efficient management systems for special structures.

➲ The knowledge generated from the project is expected to result in safe and durable structures with enhanced life expectancies.

3.2.11.2 High performance materials and construction technologies for sustainable built space (CBRI)

Providing affordable housing and building to the teeming urban and rural populations, industry and the issue of environmental friendliness and appropriate utilization of agro-industrial wastes through recycling and reuse bearing in mind the concept of sustainable development is a matter of serious concern. The proposed activities would address these concerns.

The project activities also aims to develop partnership with the building industry enabling the institute to emerge as a significant global partner, while assisting the nation in deriving enhanced and sustainable value for human habitat. The mitigation of vulnerability to hazards both in urban and rural area and enhancement of the quality of life shall be the key objective of the proposed supra-institutional project.

Research focus

- To carry out R&D studies in the field of innovative building materials/ elements utilizing agricultural, industrial/municipal wastes so as to develop new construction technologies and to create disaster resistant facilities.

Envisaged outputs/outcomes

- Value addition to municipal wastes, agro-industrial bye products and natural fibre
- Conservation of energy
- Reduction in environmental pollution
- Safety to life and property through hazard resistant buildings
- Employment generation
- Improvement in quality of life

3.2.11.3 Development of a management system for maintenance planning and budgeting of high speed road corridors under NHDP (CRRI)

Development of a Management System for Maintenance Planning and Budgeting of High Speed High Density Corridors is a very ambitious project for the nation which will help in allocating scarce funds in optimum manner for road maintenance. The development of the system requires very sophisticated / State of Art equipments which are not available in the country / with the Institute.

Research focus

- Development of a management system that can estimate budget requirements, make logical decisions about allocation of funds and decide optimal maintenance schemes within the given budget scenario including constrained budget

Envisaged outcomes/outputs

- The system planned to be developed will be very useful for upkeep of public roads in an optimal and economical way.
- The developed system will assist in reduction of avoidable losses occurring every year on account of poorly maintained roads and will provide powerful tool to the road authorities in allocating maintenance funds judiciously and in prioritizing the maintenance treatments in view of limited resources.
- The developed system will enable proper planning and prioritizing projects which will then help in quick decision-making based on sound technical and economical footing.
- Properly maintained roads will conserve energy, reduce traffic hazards and improve road safety by reducing accidents.

NETWORK PROJECTS

3.2.11.4 Track-bridge interaction studies in Indian environment (*SERC*, CRRI)

Railways play important role in the industrial growth of any nation. Research efforts in modern railway engineering are aimed at providing fast, efficient and economical transport and this is being achieved by structurally improving the vehicle and track system. Research on the moving load problems in general, and bridge–vehicle-track interaction in particular, is being carried out world over during the past two decades. However, there exists a serious gap in this domain in Indian context.

There is variety of methods for carrying out advanced analysis of such complex structural systems. There is a scope for understanding the actual behaviour of bridge-track-vehicle interaction using such aids. There exists uncertainty regarding the realistic force transfer mechanisms on the bridge from the vehicle through track. By formulating suitable instrumentation schemes, reliable force transfer mechanisms can be established.

Further, it is essential to understand the effect of the increased axle-loads and vehicle speeds on the existing bridges, since most of the bridges are old. Thus, there is a need for performance evaluation of existing bridges through analytical as well as experimental investigations.

Many a times, it is not possible to replace the existing structure due to paucity of resources. In such situations, it is essential to extend the service life of structures through various enhancement/repair and rehabilitation schemes. Further, the performance of the bearings is very important for proper transfer of load from superstructure to the piers. There is an urgent need to establish test facility for evaluation of material properties and to develop strategies to improve the seismic performance of bridges in our country.

Research focus

The elements involved in track-bridge interaction would be identified and a mathematical modeling of track-bridge interaction for different types of bridges would be developed. The existing bridges would be evaluated and strengthening methods for improving the life of existing bridges would be suggested.

Envisaged outputs/outcomes

The knowledge generated from the project is expected to result in more safe and durable bridges with enhanced life expectancies. The results of the studies will also be useful for the design of new bridges. This will benefit the society by way of safe transportation systems with less number of accidents.

INTER AGENCY PROGRAMME

3.2.11.5 Engineering of structures against natural and other disasters (*SERC* CBRI, CMERI, CRRI, NML, CMMACS, IIT Madras, IIT Roorkee, IMD, ISRO, NDMA, CPWD, VIT, NGRI)

The Indian subcontinent faces threat from many natural disasters. Earthquakes, cyclones and tsunami are common amongst them. There are also other disasters due to blast etc. Shock loads are becoming regular service loads for certain important structures like power plants, chemical plants, defense installations etc. There is need to estimate the loads and response for engineering of structures against natural and other disasters. There is no spectrum available for cyclonic winds. There are also no guidelines in India for blast loading. It is also necessary to study various damage control measures for structures for different types of disasters. Since many areas are vulnerable for more than one type of disaster, proper methods have to be established for multi-hazard prone areas for which there are no guidelines at present.

Research focus

Investigations for better estimation of loads and actions due to different hazards would be carried out and models for condition assessment of structures subjected to extreme events would be developed. Design guidelines and various measures for damage control of buildings and structures against various types of disasters would be delineated.

Envisaged outputs/outcomes

➲ Knowledge generated from the project is expected to result in more safe structures to withstand natural and other disasters. It will also help in upgrading of existing structures in seismic zones to meet the newly formed design criteria.

3.2.11.6 Computational modelling and simulation for high performance materials for engineering applications(*SERC* C-MMACS, CGCRI, Cranes Software International Limited, RRL-Tvm, RRL-Bho, NML)

Structural analysis as well as material and process development are the keys to the design and construction/manufacturing of the structural components in civil, mechanical, aerospace, nuclear and ocean engineering. Design of such advanced engineering systems requires the use of computer-aided analysis and design tools. In such tools, computational simulation techniques are often used to model and investigate physical phenomena in an engineering system. The simulation requires solving complex differential or partial differential equations that govern these phenomena.

In this connection, an indigenous software finite element analysis software, FINEART ver 3.0 was developed as an outcome of the CSIR Mission Mode Programme (CMM-20) on Mathematical Modelling and Computer Simulation. FINEART ver 3.0 has the capabilities to conduct static and dynamic, linear or non-linear stress analysis of solids and structures. Very little effort has been made to represent mathematically the bond-slip behaviour of reinforced concrete (RC) elements and the associated damage. The emerging concepts of damage mechanics need to be used to address such issues. Advanced ceramics and ceramic matrix composites are extremely promising materials for fabricating engineering components and structures with high mechanical and thermal load bearing capacities, high fatigue strength and attractive specific strength. These have a wide range of promising applications in aerospace (e.g., jet engine components), healthcare (e.g., artificial hip joints), defense (e.g., ceramic plates in vehicle armour panels) and energy sectors (e.g., solid oxide fuel cells). There is also need to develop smart and spectral finite elements and advanced techniques for higher order regimes. This thus requires continuous updating of this software with the start-of-the-art features. In view of the above needs and requirements, the project aims to develop advanced finite elements and methodologies for implementation in FINEART and release of Version 4.0.

Research focus

Updating of FINEART 3.0 developed under CMM-20 into FINEART 4.0, with the start-of-the-art features would be done for making it suitable for advanced analysis techniques for higher order regimes so that damage mechanics based models could be generated.

Envisaged outcomes/outputs

➲ The products developed as outcome of the project can be used by analysts, designers and practicing engineers in various industrial sectors.

3.2.11.7 Corrosion in oil and gas structural facilities (CBRI IIP, NML)

In oil and petroleum industry sour gas and associated condensate are received from the off shore platforms. The sour gas passes through various operational units such as gas sweating unit, dehydration unit, condensate fractional units, LPG recovery unit, kerosene recovery unit, sulphur recovery unit etc. to get products like petrol, diesel oil, jet fuel, LPG, kerosene, solvents, waxes and asphalt. For the above operations units like reactors, distillation towers, storage tanks, pipelines, pumps, and structural supports are needed.

Most of these structures are made of steel and are prone to corrosion due to highly corrosive environment of refinery, since most of the refineries are located in costal area. Apart from the highly humid/saline environment, gases like carbon dioxide and hydrogen sulphide and high temperature also adds to increase the corrosion rate. Various types of protective measures are used to minimize the rate of corrosion. Protective coating systems based on synthetic enamel, bitumen, inorganic zinc, vinyls, coal tar, coal tar epoxy, epoxies or urethanes are generally used for the above purpose. The protective coatings are used in conjunction with cathodic protection to check external corrosion of pipelines. Through proposed project it has been envisaged to develop protective system for Oil & Gas structural facilities which would help in reducing the corrosion losses and enhance the life of structures and at the same time improvement in safety would also be achieved.

Research focus

The corrosion behaviour of the oil and gas structural systems for onshore structures would be investigated so as to develop environment specific coating systems for the protection of steel structures.

Envisaged outcomes/outputs

- Data on corrosion losses in structures exposed to different environment
- Protective coating systems for various steel structures.
- Developed protective system will help in reducing the corrosion losses and enhancement in the life of structures
- Improvement in safety

3.2.11.8 Development of value added materials and processes for building industry (*CBRI*, SERC, CRRI)

The consumption of traditional construction materials to meet demand of housing is rising exponentially and unable to fill the staggering gaps of new requirements. It is essential that these materials constitute about two-third of the total construction cost. Attention on judicious approach for selecting appropriate standardized materials and linking their production to sustainable environment oriented development also becomes the necessity in the rapidly changing environment. Many projects of building materials based on imported technologies closed down with colossal financial losses as they proved to be highly energy intensive and incompatible with the physical properties of the local materials. A consensus is, therefore necessary to meet these challenges by developing alternative materials and technologies, which lead to obviating the material short fall through enhanced productivity.

The availability of environmental building materials vis-à-vis to new or modified materials has different properties and durabilities. Though, these building materials comply with the relevant standards and requirements, they do not instill confidence with the users due to inadequate strength, durability, environmental compliance etc. There is a staunch necessity to evolve processes and technologies for new and alternative high strength and durable building materials to gainfully utilize the agro industrial wastes to longer extents and to save our environment.

Research focus

Six major areas have been identified for R&D developmental activities. The area are related to development of : (i) Cost effective and value added products of Cement and Concrete (ii) Building Materials from Agro-Industrial Waste Products (iii) Wood Substitute Materials, (iv) Repair Materials, (v) Standardized Building Materials and Components and (vi) RC structures components.

Envisaged outcomes/outputs

- The developed materials would be expected to provide alternatives at affordable cost to conventional materials with an improved level of durability.

3.2.11.9 Energy efficient structural systems(*CBRI*, CGCRI, SERC)

Buildings consume substantial amount of energy during their construction, maintenance and running for optimum physical comfort to its occupants. It becomes essential therefore, to develop a methodology for designing and assuming the energy requirements of construction system and optimized the energy saving potential of such system in different climatalogical sectors of the country.

Research focus

The proposed work has been divided into the following sub areas:

- Investigation of the Energy Saving materials & devices for application in buildings.
- To develop methodologies for planning and design of energy efficient buildings.
- Survey of significant energy efficient buildings in India. Collection of data and feed back from users on various parameters & their analysis.
- Study on embodied energy during construction of buildings & its components.
- Performance and evaluation of energy efficient building utilizing available software.

Envisaged outputs/outcomes

- Design Guidelines for Energy Efficient Buildings
- Design of Options for Different Climatic Regions
- Energy Saving & Comfortable Environment

3.2.11.10 Proactive vulnerability mitigation methodologies (*CBRI*, CSIO, CMRI, NGRI)

The Himalayan mountain-building process is still continuing and as a result, it is frequently subjected to several natural hazards like earthquakes, landslides, avalanches, glacial lake outburst floods, flooding etc. These natural hazards are posing serious problems particularly in the state of Uttaranchal, where the means of mitigation and corrective measures are scarce.

In the reverse process of land use changes in geographic and economic trends disturb the delicate balance of the ecosystem of the mountain environment leading to increase in the gravity of risks and frequency of hazards. Further the introduction of modern infrastructural facilities that are built without taking into consideration of potential hazards has increased the probability of extensive damage. There is lot of policies and investments in mountain roads and other types of infrastructure without the accompanying concern about environmentally-friendly construction. The more localised disasters have increased because little allowance was made in engineering techniques for how hazard-prone an area might be.

Disaster mitigation requires better understanding of the physical nature of the region and the impact of human activity, with integration of knowledge from such diverse fields as geology, geophysics, engineering, hydrology, and meteorology to achieve more effective natural disaster prevention and mitigation and thereby minimizing the risk.

Hence evaluating the hazards and risks due to earthquake, landslides and flash floods in Uttaranchal Himalaya and finding solutions to minimize the quantum of disaster is imperative.

Research focus:

The objective of the proposed program aims at evaluating the hazards and risks due to earthquake, landslides and flash floods in Uttranchal Himalaya and finding solutions to minimize the quantum of disaster. In other words the study will focus on multi hazard risk assessment to help disaster mitigation and management, which involves landslide hazard assessment & mitigation, seismic hazard & risk analysis and risk of flash floods in Himalayan rivers.

Envisaged outcomes/outputs

- Knowledge generation of hazard and risk assessment for different types of potentially disastrous natural events
- Seismic and landslide hazard maps for Uttaranchal
- Development of Seismic warning system
- Methodologies for multi-hazard risk assessment

INTER AGENCY PROGRAMME

3.2.11.11 Research paradigms using accelerated pavement testing facility (*CRRI* IIT-Kanpur, IIT-Kharagpur)

Accelerated Pavement Testing Facility is a very ambitious project for the nation which will help in evaluating the accelerated testing of pavements for varying loads and environmental conditions for time series performance observations on selected sections and development of model for fatigue and rutting criteria for various types of overlay. Operational expenses are also required for consumable items like test beds, load cells, sensors and salaries of temporary manpower. High recurring cost is due to requirement of procurement of sensors for measuring temperature, moisture, load, pressure etc. These sensors will get embedded in the pavements/ test beds and hence are considered as consumables. Other reason is high annual maintenance and operation cost of the facility, and need of engaging expert manpower to handle the facility.

Research focus

Performance characterization of designs and specifications using various materials followed in India, would be reviewed using the Accelerated Pavement Testing Facility and equivalency factors for various pavement layers of different thickness and under different types of sub-grade would be determined. Efforts would be made to increase permeability of porous asphalt mix surfacing, during wet weather conditions and to increase skid resistance.

Feasibility studies for using recycling techniques of bituminous layers by use of foam bitumen and insitu recycling to eliminate the problems caused by rising surface levels of roads during strengthening of flexible pavements in urban areas would also be carried out. R&D studies would be carried out to find out new type of bituminous mixes that can be used, for heavy duty corridors particularly, on National Highways and suitability of use of building demolition wastes for construction of road construction would be investigated.

Envisaged outcomes/outputs

- In generating knowledgebase in reinstating or modifying prevalent design methodologies and specifications.
- Savings of materials particularly aggregates thereby reducing the cost of pavement construction and maintenance.

3.2.11.12 Development of traffic management centre (TMC) and application of intelligent transport system for Delhi region (*CRRI*, AITS Bhopal, Delhi College of Engineering in association with a consortium of ITS companies of European Commission (EC), MoUD, NDMC, MCD, Delhi Traffic Police)

A person living in Delhi spends many hours on road every day, simply commuting between home and office and therefore there is need to have a traffic management centre, which can provide useful information to the public transporters & commuters so traveler delays are reduced, and operator costs are reduced. Better road safety, environmental conditions, parking management, would prevail. Advance information about traffic congestion, incidences etc. through variable message signs would help the society both in qualitative and quantitative terms.

With Commonwealth Games 2010 on the anvil, Traffic Management Centre using ITS would be the answer of many problems/issues in Delhi. Since a lot of investment is being made for the organization of the Games, traffic management holds the key role in effective and productive holding of the event.

Traveler Information Centre which will collate information from various public transport agencies (buses, metro), traffic management centre, railway and airlines operations etc. can transmit the information consistently over ubiquitous communication channels, like the internet, telephone, radio, television, Variable or Dynamic Message Signs.

Research focus

Traffic Management Centre for Application of Intelligent Transport System for Delhi at Network Level for identified major corridors in Delhi for would be developed for providing useful information like congestion mitigation, parking management, toll collection, information on direction and destination through variable message signs, emergency management, commercial vehicle management, noise management system and emission reduction

Envisaged outcomes/outputs

- Savings in funding for capacity augmentation of road construction which otherwise would be necessary for handling traffic congestion.
- Increase in transit ridership and reduction in operator costs would certainly benefit the private stakeholders.
- Intelligent logistic management to reduce the impact of commercial vehicle movement would help in effective coordination of commercial vehicle operations and management.
- Electronic toll collection would also add to the interest of the private entrepreneurs and government for levying different taxes.
- Efficient and effective emergency operations using ITS is expected to help in saving critical lives in the event of occurrence of any road accident. Its critical role in post-disaster management cannot be ignored.

3.2.11.13 Performance evaluation of highway and railway bridges (*CRRI,* SERC, NML, CECRI, MOSRTH, NHAI, State PWDs, SE Railway, Northern Railway, Eastern Railway)

The project envisages comprehensive performance evaluation of highway and railway bridges. Since India has a lot of old bridges, their performance evaluation will ensure their usability and hence the project stands its feasibility.

Research focus

The performance of existing bridges under increased axle loads, environmental effects and seismic loads would be evaluated.

Envisaged outcomes/outputs

- Knowledgebase in developing methodologies for strengthening and rehabilitation strategies for bridge components alongwith the guidelines for load carrying capacity of bridges would be generated.

3.2.11.14 Multi functional additives to cement for faster setting and imparting anti algal and self cleaning surface properties. (*RRL Thiruvananthapuram,* SERC)

RRLT has already developed photo active titanium oxide for a variety of applications, catalysts, coatings on glass, anti algal coatings on roofing tiles made from terra cotta and demonstration of the process has been completed. There is much literature available with respect to cements, although indications are available for such research activity from developed countries.

Cement is most widely used in construction and in external applications, the surface needs to be painted very often in order to make it non wetting and also to prevent growth of algae and other contaminants from the environment. Special grades of titanium oxide is known to photo catalytic which is demonstrated by its capacity to prevent growth of algae and to decompose organic contaminants adhering to the surfaces of glass, plastic and ceramics. Such property is generally known as “self cleaning”. Further, nano particles are also known to promote setting of cement resulting in high strengths.

Research focus

It is proposed to develop high strength, fast setting cements and plasters having minor additions of photo-catalytic titanium oxide which will have multi functional effects, such as acting as nano additives as well as promoting self cleaning property. Such smart cements are proposed which will have wide applications in external structures and coatings, marine and humid environments and in tropical climates.

Envisaged outputs/outcomes

➲ Smart cements developed would find wide application in external structures and coatings, marine and humid environments and in tropical climates.

NATIONAL FACILITY CREATION

3.2.11.15 Establishment of national facility for remote structural health monitoring (SERC)

Remote Structural Health Monitoring (RSHM) is the evolution of onsite structural health monitoring, in which the remotely located structure is continuously monitored from a monitoring station situated at a different place in real-time and with less human intervention.

One of the major advantages of RSHM is simultaneous monitoring of a number of structures, which are geographically located at different places, from a centralized monitoring station. In addition to the above, it has the advantage of collection of uninterrupted measurement of data even in case of natural or other calamities (such as cyclone, earthquake, flood, accidental loads etc.) until it directly damages the instrumented structure or monitoring station.

RSHM takes the advantages of the rapid development in communication and information technology for efficient monitoring and advance warning features and hence creation of national level facility in this area is essential. The necessity of RSHM is all the more important as there is rapid and simultaneous growth of construction of civil infrastructural facilities across the country at an unprecedented rate.

SERC has been working in the area of structural health monitoring since decades and the current Five Year Plan, R&D efforts were focused on development of state-of the-art methodologies. It has thus considerable expertise already in this area and large knowledge base.

Aim of the facility

➲ Creation of a World Class State-of-the-Art National Facility at SERC for Remote Structural Health Monitoring

3.2.11.16 Centre of excellence for advanced structural materials (CBRI)

Aim of the centre

The performance of material is one of the most important aspects that need a better understanding for a sustainable infrastructure. There have been several limited attempts to look at this in specific perspective. The present efforts to ensure that a comprehensive evaluation is possible through a coherent & in depth so that better materials of very high performance can be developed for structural system in future.

Envisaged outputs/outcomes

- High level of scientific knowledge.
- Technology development and cost effectiveness.
- Life enhancement & reliability.
- Better standards of living.

Total Plan budgetary requirement projected for the Sector is Rs. 445 crore

3.2.12 INFORMATION: TECHNOLOGY, RESOURCES & PRODUCTS

In recent times, 'software development and IT enabled services' have emerged as a niche opportunity for India in the global context and is the fastest growing segment of Indian industry both in terms of production and exports. The Government is taking all necessary steps to make India, a Global Information Technology Superpower and a front-runner in the age of Information Revolution. With this objective in view, the Government has announced promotion of Information Technology as one of the five top priorities of the country and constituted a National Task Force on Information Technology and Software Development.

Recognizing great potential of IT, during 9th five year plan CSIR created IT sector as a separate thrust sector. It was in this plan period that URDIP was set up. Further, during 10th Five Year Plan NISCOM and INSDOC were merged in order to consolidate and effectively synergies their core competencies in IT sector.

The objectives of the XI plan would be achieved through various strategies and approach which include; working with institutions/agencies outside CSIR in network mode in multi disciplinary areas; supra-institutional projects wherein the majority of the groups of the laboratory work together for a flag ship project that would synergize the in-house capabilities to optimize the outputs; and further strengthening of networks among CSIR labs to develop product and process of interest to the nation.

NETWORK PROJECTS

3.2.12.1 Comprehensive Traditional Knowledge Digital Library *(NISCAIR)*

The TKDL project seeks to protect India's Traditional Knowledge, prevents misappropriation of India's rich heritage of traditional knowledge. Under the project, public domain traditional knowledge is being documented and digitized for use of International Patent Office in five International languages viz English, French, German, Spanish and Japanese.

Research focus

The activities of CTKDL to be enhanced to include:

- Traditional music, traditional handicrafts and traditional cultural expressions,
- TK patent watch unit,

- ➲ Documentation of Tibetan system of medicine,
- ➲ Marine biodiversity digital library and microbial diversity digital library, and,
- ➲ Digital database on reflexology.

Envisaged outcomes/outputs

(i) Traditional Music

- ➲ The traditional music of India includes multiple varieties of folk, popular, and classical music. India's classical music tradition, including Carnatic and Hindustani music, has a history spanning millennia and, developed o ver several eras, remains fundamental to the lives of Indians today as sources of religious inspiration, cultural expression and pure entertainment. Other highly popular forms are ghazal, qawwali, thumri, dhrupad, dadra, bhajan, kirtan, shabad, and gurbani. Indian genres like bhangra have become popular throughout the United Kingdom, South and East Asia, and around the world. The present musical style is derived from the traditional musical accompaniment to the folk dance of Punjab called by the same name, *bhangra*.
- ➲ Digital documentation of knowledge on TK will be done by including the existing and practiced knowledge and information about the knowledge holders in an internationally accepted format. Photographs and video clippings will be included wherever necessary. The areas where digital documentation of the knowledge will be done will include:

(ii) Traditional Handicrafts

- ➲ Traditional Handicrafts are the products that are produced either completely by hand or with the help of tools. Traditional Handicrafts are made from raw materials from sustainable sources. Such products can be utilitarian, aesthetic, artistic, creative, culturally expressive, decorative, functional and religiously or socially symbolic and significant. Some of the Traditional Handicrafts of India which will be documented in the database on Traditional Handicrafts include:
- ➲ Metal crafts: Brass, copper and bell metal or other metals shaped into intricately designed images, idols, jewellary and utility items, having a finish and style unique in appeal.
- ➲ Stone Craft and Marble Inlay Work: Blocks of stone cut, shaped, inlaid and polished into beautiful objects.
- ➲ Wood Craft: Wood carving, or sculptures, etc.
- ➲ Precious and Semi Precious Stones: Precious or semiprecious stones created and used by the indigenous people
- ➲ Painting: Rock painting in caves are the earliest specimens, and folk- art, as conventionally understood.
- ➲ Textiles: The traditional textiles of India demonstrate skilful weaving techniques, inimitable color combination and fascinate designs that make them a class apart.
- ➲ Furniture: India’s huge forest land boasts of a wide variety of trees ,the wood of which have been used for designing and making Traditional furniture.
- ➲ Floor Coverings: Traditional floor covering used in India.
- ➲ Pottery: Eye-catching articles of functional and decorative value are fashioned by the traditional skilful potters of India.

(iii) Cultural Expressions

- ➲ Traditional cultural expressions, often the product of inter-generational and fluid social and communal creative processes, reflect and identify a community’s history, cultural and social identity, and values. Expressions of traditional culture (or 'expressions of' folklore') may be either intangible, tangible or, most usually, combinations of the two.

- productions of fold art, in particular, drawings, paintings, carvings, sculptures, pottery, terracotta, mosaic, woodwork, metalware, jewelry, basket weaving, needlework, textiles, carpets costumes;
- crafts;
- musical instruments;
- architectural forms.

(iv) TK Patent Watch Unit:

- The Traditional Knowledge Digital Library database will be made available to Patent Examiners at the international Patent Offices. For providing access, the approval has been given by the Cabinet Committee on Economic Affairs in June, 2006.
- It has become essential create a Patent Watch Unit which will have the following responsibilities:
- To monitor the international patent databases and the applications filed in the international patent offices for the patents taken which are from Traditional Indian Systems of Medicine
- To examine the TKDL database for the identification of wrong patents filed at the international patent offices
- To correspond with the patent offices giving evidence of misappropriation based on the TKDL database
- To prepare monthly reports which may provide the details of the cases identified where traditional knowledge information has been misappropriated
- The team may also get horizontally integrated with the international patent offices for search and examination based on the requirement expressed by the international patent offices.

(v) Documentation of Tibetan System of Medicine:

- Tibetan medicine is a traditional system of medicine which has been practiced for over 2500 years. Tibetan medicine is one of the five major sciences, and it is called *gSoba Rig-pa*, the science of healing. It uses different kinds of ingredients such as herbs, trees, rocks, resins, soils, precious metals, saps etc.The headquarters of the Tibetan Medical and Astrological Institute are now based in Dharamsala, North India. It is here that all the Tibetan doctors now receive all their training, and it is also where the medicines are manufactured. At present there are now over 30 branches in India and Nepal, and in addition to this there are a number of private clinics. Tibetan medicine still survives in Tibet.
- Tibetan system of medicine also needs to be protected against misappropriation. However, it also needs to be preserved. A Task Force will be constituted which will examine the work load, budget requirements, project implementation plan, monitoring, etc. for creation of the database on Tibetan System of Medicine.

(vi) Database on 'Treatment (Ayurveda)

- Creation of the database on Treatment (Ayurveda) will be implemented. The database on Diseases, Causes and Symptoms will be used for creating this database. This database will be valuable for practitioners of the Ayurvedic system of medicine.

(vii) Marine Biodiversity Digital Library:

- The Indian Ocean is the third largest ocean in the world, occupying 21% of the global ocean area. This environment is a rich source of both biological and chemical diversity. This diversity has been the source of unique chemical compounds with the potential for industrial development as pharmaceuticals, cosmetics, nutritional supplements, molecular probes, fine chemicals and agrochemicals. In recent years, a significant number of novel metabolites with potent pharmacological properties have been discovered from the marine organisms.
- Although there are only a few marine derived products currently in the market, several new compounds from marine origin are now under clinical trials for drug development. While the marine world offers an extremely rich resource for novel compounds, it also requires multidisciplinary approach to bring the marine chemical diversity up to its therapeutic potential.
- The creation of database on Marine Biodiversity Digital Library particularly with respect to medicinal value will be taken up in networking mode.

(viii) Microbial Diversity Digital Library:

- Creation of the database on Microbial Diversity will also be taken up in network mode. Feasibility for carrying out this activity particularly for those microbes, which have therapeutic potential in networking mode is being worked out in collaboration with RRL, Jorhat, IMTECH.

(ix) Digital Database on Reflexology:

- Reflexology is one of the little known methods of treatment of human ailments and perhaps had its origin in India. Detail studies are being carried out for finding the possibility of creating a digital database on reflexology. The tentative objective of the work will be to preserve and popularize the treatment concepts and methodology based on reflexology.

3.2.12.2 National Science Digital Library (*NISCAIR*)

National Science Digital Library (NSDL), the first of its kind in the country, envisages to provide e-access to digital resources to students, particularly in the remote areas.contribute to the national development by reaching the un-reached students in the remote areas, by providing them e-learning facilities and access to quality curriculum based material at a level similar to that available to students in metros.

Research focus

- Creation of courseware content for engineering, medical and 10+2 level students
- Developing other content such as competitive examination material, solved question papers, interactive e-learning modules
- Consolidating the data centre and other ICT infrastructure in the project
- Promotion of the NSDL portal

Envisaged outcomes/outputs

- NSDL will evolve once the entire process stabilizes into an education portal to serve the curriculum based needs. NSDL of the future will give access to a large variety of multimedia and multi-type documents created by integrating content from many different heterogeneous sources that range from text, images, audio-video repositories, to scientific data archives, databases, and program repositories.

- ➲ The digital library will provide a seamless environment where the co-operative access, filtering, manipulation, generation, and preservation of these documents will be supported as a continuous cycle. Users of the library will be both consumers and producers of information, either by themselves or in collaborations with other users. Policy ensuring mechanisms will guarantee that the information produced is visible only to those stakeholders that have the appropriate rights to do so.
- ➲ Another goal of NSDL will be for education and training purpose using the Internet as the medium to deliver e-learning. NSDL will also have Virtual Meetings & Presentations, Live Chat &Threaded Discussions, with facilities for Call In During Live Lectures

3.2.12.3 Consortium access to electronic journals for the benefit of CSIR labs (NISCAIR)

Knowledge is a very vital and essential input for scientific research and development. There is a flood of information resources today. Journal titles are increasing three folds every 15 years and costs of journals are growing at a rate 2.5 times every ten years. Similar is the growth in databases and other information resources too. With the convergence of IT and communication technologies, there is a shift from traditional print to online electronic sources. Electronic resources offer tremendous possibilities and advantages over print**.**

Research focus

- ➲ To provide CSIR S&T staff, electronic access to world S&T literature to strengthen the facilities for pooling, sharing and electronically accessing the CSIR information resources.
- ➲ To expand the R&D information resource base of CSIR laboratories/institutes comparable to world leading organizations.

Envisaged outcomes/outputs

- ➲ Electronic access to world S&T literature

3.2.12.4 E-Access to databases (*NISCAIR*)

It is known that R&D organizations and universities in India spend most of their library budgets on subscriptions to primary and secondary journals. Even then very few institutions in India may have access to online bibliographic databases. Evidently, bibliographic and other required databases are essential tools for R&D work. Hence, it is proposed that CSIR should go in consortium mode for few of the bibliographic databases, which are essentially required by all labs/ institutes.

Research focus

With the development of information and communication technologies, the Abstracting and Indexing periodicals have evolved into online bibliographic databases. R&D organizations and universities in India spend most of their library budgets on subscriptions to primary and secondary journals and very few institutions in India have access to online bibliographic databases. There is a spiral rise in number of journals, patents, standards, databases etc. The cost of these resources has also increased, however, the budget of libraries have not grown proportionally. This has forced libraries to reduce their subscription levels, resulting inadequate information support to the researchers. To address this problem, it is proposed that CSIR should go in consortium mode for the bibliographic databases, which are essentially required by all labs/institutes. These databases are: Web of Science (WOS), Derwent Innovation Index (DII), International Patent Documentation Center (INPADOC), Delphion and standards - ASTM & Indian Standards.

Envisaged outcomes/outputs

- The E-sources would become available round the clock and access to them would not be constrained by limited library timing or the physical boundaries. The R&D workers of CSIR can access information at desktops from any place in the laboratory, and not just from the library. This unlimited and unbound access to a wide range of information would lead to knowledge generation and intellectual property assets and positioning of CSIR and its laboratories in the global R&D platform. The Web of Science (WOS), Derwent Innovation Index (DII) are useful tools to search and evaluate the S & T output of individual, institutional and CSIR as a whole. I

3.2.12.5 Development of a data analysis, management and outreach (DAMO) platform by integrating database, outreach algorithms and information technology for large user base. (*CMMACS)*

The projects aims at developing an integrated weather informatics and outreach system by integrating and developing necessary components; modelling, outreach algorithms and decision support systems and develop algorithms and software for data mining, data management, data archival and data analysis as well as automated large network web-based dissemination.

Research focus

- To develop an integrated weather informatics and outreach system by integrating and developing necessary components: modelling, outreach algorithms and decision support systems.
- To develop algorithms and software for data mining, data management, data archival and data analysis as well as automated large network web-based dissemination

Envisaged outcomes/outputs

- A complete web-based portal for weather and climate informatics and services.

3.2.12.6 Web portal on plant and animal diversity in India (*NBRI*)

About 19 CSIR laboratories are engaged in generating, managing and building data related to Indian bioresources. Several of these laboratories do have databases developed on specific aspect of biology, biodiversity, bioresources and ecosystems, etc. However, this information is scattered in several structured and unstructured information sources, which are distributed, heterogeneous. These are developed on different platforms, using variety of database management systems and also follow different format content types, database structure (data models), as well as access mechanism.

This proposal proposes development of a web portal on floral and faunal diversity of India for interconnecting the existing databases in CSIR system and a few important herbaria like ICFRE, TBGRI etc. and finally establish global linkage in the leadership of CSIR.

IBIF portal will disseminate information on microbes (Fungi, Bacteria, & Plant Viruses) lower plants (Lichens, Bryophytes, & Pteridophytes) and higher plants (Gymnosperms and

Angiosperms) and animals. It will establish linkage of various databases and finally establish link with GBIF.

NCL will focus on faunal database and will undertake value addition on 90000 species of Indian fauna and will interact with all participants for value additions in faunal diversity data and finally will be linked to main portal.

Research focus

- To develop interactive, interoperable and multifaceted database on floral and faunal diversity in India.
- To design database structure for creating database containing information on I- Taxonomy (nomenclature), Ecogeography, Descriptors (morphology, pollen morphology), Conservation and Environmental Biology, Physiology (Metabolic pathways), Microbiology, Pharmacognosy, Phytochemistry, Bioprospecting-biotechnology, tissue culture, Genomics, Gene expression, DNA sequences, Protein sequences, DNA profile, Human dimensions-economic utility, ethno botanical uses, traditional knowledge, community based efforts, IPR, II- Herbarium specimens, III- Living collections, IV- Germplasm, V- Images and VI- distribution maps, etc.
- To design genomic – physiological – biochemical – metabolomic networks and their analysis tools to facilitate building of models predictive of homeostatic and epigenetic effects in biological systems.
- To develop database management OS independent software for populating the database using data entry, data validation and data porting techniques.
- To collect and compile both primary, secondary data available at NBRI and other CSIR labs and establish linkage with other ongoing National efforts.
- To make software/database available on-line by telecommunications and distribute whole or in parts for personal or institutional use on subscription basis.
- To establish NBRI web portal to provide on line access on IBIF and establish on line e-learning center on IBIF and release e-Newsletter for IBIF information dissemination for benefit of students, researchers, policy and decision makers, private sector and industry and help in preventing biopiracy.
- To establish compatibility and link with other and international database network viz., GBIF, APTMNet, GSPC, IOPI, Systematic Agenda 2000, and Species 2000 etc.

Envisaged outcomes/outputs

- Six manuals on Data Standards, Dictionaries, & Structure for developing databases on Plant and Animal Diversity of India.
- A Dynamic web-Portal on plant and animal diversity in India and biological systems for management of Biodiversity of India.
- A IBIF Software, unique and OS independent
- Ten Electronic catalogues of Fungi (14500 sps.), Bacteria (850 sps.), Virus (695 sps.), Algae (6500 sps.), Bryophytes (2890 sps.), Lichens (2050 sps.), Pteriophytes (1100 sps.), Gymnosperms (64 sps.), Angiosperms (17500-Name and geography) and Animals (90000).
- Nine Electronic Monographs on Astragalus, Berberis, Caragana, Citrus, Euphrasia, Ixora, Mahonia, Oxytropis, Pedicularis etc. of India.
- Online E-learning Centre
- Plant Diversity India specialists Network
- Faunal Diversity India specialists Network

- PDI Web servers
    - Plant Names server (125000 names)
    - Image server
- Herbarium specimens – 7,90,000 specimens
- Living collections in Botanic Gardens - 100 Botanic Gardens, 20000 taxa
- Metabolic pathways network and analytical tools.
- Transcriptional pathways and gene regulatory network and analytical tools.

3.2.12.7 Cheminformatics & Patinformatics (*URDIP*)

Drug discovery paradigm in the world has changed. Long drawn synthesis and testing methodologies have been replaced by combinatorial chemistry approaches. This has been added by availability of databases as well as use of computational techniques in chemistry. This reduces the time to develop all new drugs. The development and use of databases and software tools is emerging as new area of research that is called Cheminformatics.

Research focus

- Design and develop a Networked programme in the area of Cheminformatics with a view to create specialised tools and libraries for Structure based pharmacophore searching, in silico and molecular modeling, combinatorial libraries, Virtual screening, QSAR Quantitative Structure Activity Relationships, molecular manipulation and processing, property prediction and ADME/Tox solutions.
- Create a National Centre of Excellence in the area of Patinformatics.
- Design and Implementation of One year Diploma course in Patinformatics
- Training Programmes for academia and industry.
- Creation of specialized value added Patent Databases
- Advisory services in IP Search and Analysis
- Prepare technology scenario and research gap reports
- Help industrial research labs in patentability and licensing issues in emerging technologies

3.2.12.8 ICT Infrastructure & Services — Scientific knowledge grid, high performance data centres for CSIR laboratories (*IT Division*)

The Information Technology Division, CSIR Headquarters, has the mandate to help make CSIR IT-savvy, utilize Information Technology (IT) for efficient and effective management of CSIR, showcase available expertise and knowledge in CSIR system, utilize IT to realize economy of scales in common functions in a transparent manner, establish a digital document based decision support system, and serve as a state-of-the-art data centre.

CSIR’s project under the TFYP Scheme had the following major objectives:

- To meet the CSIR requirement for collaborative research and modernization of ICT infrastructure of CSIR and its laboratories to leverage R&D activities;
- To provide support to high-end Technology in developing scientific management Grid solutions;
- To create an enabling environment for networked project implementation and management;

- To provide necessary ICT infrastructure for Scientists/Technical officers/Staff to manage various activities of CSIR in a more efficient and effective manner;
- To integrate 38 Laboratories in virtual organization by utilizing ICT-based technology and infrastructure;
- To establish a system for managing, reporting and decision-making functions related to Administration, Finance, Stores & Purchase etc.

Research focus

- ICT infrastructure
- The project was approved in January 2006. Tender Document for empanelment of Vendors for IT Hardware and Networking Components has been prepared and is being vetted. NIT to be released to facilitate Labs to procure PCs, servers, networking and related services required under the project.
- Spill-over to Eleventh Five-Year Plan
- Integration of all 38 Laboratories into a virtual organization by implementing secured ICT-based technologies and infrastructure
- Integration of e-finance, e-procurement, e-administration and e-record
- Only ICT infrastructure proposed in the Tenth Five-Year Plan will get implemented
- Establishment of CSIR Data Centre/Disaster Recovery Centre as the approved location for Data Centre/ Disaster Recovery Centre
- *Training & Handholding:* Training of users on ERP and other applications to be developed and implemented. Re-training in selected areas of IT such as application security, network security, anti-hacking, usage of open source technology and other technologies to manage IT functions, and management of training assets.
- *Bandwidth & VPN:* Provision of the bandwidth at Laboratories is not under the project, however, the Labs will make arrangements for minimum 2 Mbps bandwidth for their VPN connectivity to Data Centre and CSIR wide network. For the VC facility ISDN Links are also being provided at Lab-level for back-up from Lab reserve funds.
- *ERP:* Implementation and training of e-Procurement, e-Finance, e-Administration e-Records and e-Projects in all the Labs of CSIR.

New Activities for Eleventh Five-Year Plan

- CSIR's R&D activities are information and computation intensive. These involve such methods as analytics, and data mining & extraction. State-of-the-art computer and data facilities will be created and the existing resources will be integrated to enable a powerful Grid.
- R&D intelligence and analysis require heavy data mining, data intelligence and data exploitation. Therefore, it is extremely important that CSIR establishes adequate ICT infrastructure to fill up this gap. Three new ICT projects are being proposed to fill this gap.

Project 1: High Performance Data Centres (HPDC) at select locations to be used by all National Laboratories

- To maintain a diverse array of databases, computing, storage, and Web server resources dedicated to specific programs and internal development efforts. These include support to projects in bioinformatics research and services, data mining, digital libraries, and software for grids and clusters. It will enable researchers to work on a range of computationally challenging science and engineering applications and cut down the time between idea and IPR. Four such HPDCs will be established.

Project 2: Create capabilities in developing large-scale data technologies

Develop expertise in large-scale scientific data technologies to conduct programs in research, development, and deployment of all parts of the "data stack"—from storage configuration, file system and database development, and data services to data visualization and data-oriented portals and interfaces using an end-to-end approach to developing and deploying data technologies. Four such data centres will be created.

Project 3: Establish knowledge management system to integrate, analyze, model and visualize multidisciplinary data-sets in fields like geosciences, ecology, environment etc.

Create powerful capabilities that help scientists and engineers advance from data and information to knowledge, distilling vital insights from a deluge of data in large-scale collaborations such as in Geosciences, Ecology and Environment—developing technologies that enable researchers to integrate, analyze, model, and visualize complex multidisciplinary data sets. Four such knowledge management centres will be established.

Envisaged outputs/outcomes

- Research related information would be widely accessible to a wide range of S&T and academic community in the country through ICT tools and devices. Building e-Science Knowledge Grid will lead to accelerated research by forging partnership and exploring new methods and technologies. The Data Centre would also act as a state-of-art facility for collaboration among scientists, researchers and technologists involved in network R&D projects.
- This project will build the basic infrastructure and Grid to access and share the resources to support the researchers to achieve their goals. Thus, new knowledge created and novel technologies/methods developed would ultimately lead to industrial development and the society would certainly be benefited. The project will integrate ICT into R&D in science by changing the ways of creating new and more relevant Intellectual Property.
- Knowledge Grid infrastructure will improve the internal and external processes of CSIR. The benefits of a fully integrated and scaled up Lab Management System are to:
- Provide Grid services through open Grid infrastructure for optimum use of capital expenditure in computing resources
- Provide cost effective computing resources required for scientific research by enabling Grid infrastructure networked on high-speed links
- Provide Internet connectivity to all Laboratories through a high-speed Virtual Private Network connecting all Laboratories to a common Network Operations Centre thus creating a virtual organization with a common focus
- Provide adequate bandwidth with high speed connectivity to all R&D departments and administration cells in Laboratories
- Provide access to E-mail, Web-based services, high-bandwidth applications such as audiovisual content
- Act as knowledge management system to manipulate knowhow and technology information with advanced data mining tools for decision-making relating to vital R&D issues and options
- Provide seamless connectivity between Laboratories and CSIR Hqrs for critical transactions such as HR, project management and resource sharing and allocation
- Facilitate annual budget estimation and implementation of uniform cost monitoring measures

- Manage the flow of materials, equipment, scientific processes and faster administrative clearances to save time
- Provide superior project management tools for managing CSIR's R&D programme and network projects
- Connect VC and IP Phones to same high-speed links to facilitate effective communication between the Laboratories as well as with CSIR Hqrs. Cost effective options for long distance communication, meetings, presentations and recruitment, training, seminars and HRDG functions
- Provide multimedia facilities for research including access to Grid for scientist-to-scientist video conferencing
- Provide on-demand access to virtual training programs and workshops thus multiplying the benefits of such efforts manifold
- Aid capacity building through virtual learning system on the web in collaboration with leading academic national and international institutions and providing training and skill upgradation programme on demand.
- The project is not to accrue benefits directly; it is an essential infrastructure service to provide support to the researchers who do not have adequate access to the trans-boundary computing resources and S&T information. The project will strengthen and improve the services to the users by providing the necessary support to research in science by Grid computing, HPDC, Data Centre and knowledge management infrastructure.

3.2.12.9 e-records system for CSIR and its laboratories (*IT Division*)

The basic objective is digitization of Information in CSIR and its laboratories. CSIR is making concerted efforts to maximize the use of modern ICT. It has embarked upon several projects, which are based on modern IT techniques, and has made commendable progress in the area of knowledge networking and science communication.

Under the 11th Five Year Plan it is proposed to institute a system of e-Records for Electronic Storage and Retrieval of Records, primarily to meet the RTI obligations and also to warehouse the documents related to Scientific R&D.

Section 4(1a) of the RTI Act propounds that "Every public authority shall maintain all records duly catalogued and indexed in a manner and in the form which facilitates the right to information under this Act and ensure that all records that are appropriate to be computerized are, within a reasonable time and subject to availability of resources, computerized and connected through a network all over the country on different systems so that access to such records is facilitated".

Research focus

- Identification of "Information" to be digitized
- Creation of e-records i.e. Digitization of information
- Creating an infrastructure to store, retrieve and distribute information easily
- Training the Manpower
- Besides the information related to Administration, Purchase, Finance & Projects it is also envisaged to digitize and store the Scientific R&D Documents.
- System and procedure for digitization

- After identification of suitable documents in the laboratories, the same may be scanned the documents at a specified scanning station identified for the purpose in each of the laboratories. To ensure uniformity and compatibility, it is advisable for all the laboratories to adopt open standards and as far as possible utilize similar specifications for the digitization process.
- The scanning activity shall be two fold -- one for the current documents and the other for the older documents.
- A common web-enabled software interface shall be developed, which will be used to upload the digitized documents and also add the metadata of the documents scanned. For the citizenry to access the information, the uploaded data may be accessible from the CSIR website or from the website of the respective laboratory.

Envisaged outcomes/outputs

- Efficient and long-lasting storage and retrieval of the records.
- Meeting the RTI Obligation maintaining the history/archives.

3.2.12.10 World Science Watch (NISCAIR)

There is a growing realization today that knowledge is central to a country's productivity growth and societal betterment, and is increasingly becoming the key-differentiating factor between economies that are positioned to grow rapidly and those that are not. With globalization and the new world economy, there has been a rapid move to a knowledge-based society. In the decades to come, technological changes and competition will accelerate. If the country has to meet the challenge head-on, it must be able to keep a track of S&T developments the world over and anticipate technological changes and based on that draw up a road map to move on. However, without authentic and reliable data neither can meaningful policy decisions be taken nor can long-term plans be drawn.

With the country's scientists working in diverse R&D work areas, there is a need to undertake such exercises that enable the country's researchers to take up more meaningful projects and help policy makers in drawing up developmental plans in a more effective manner. This calls for access, collation, monitoring, and analysis of S&T research being carried out in various fields throughout the world and provision of this information to the country's research community in the form of position papers. This will not only give the researchers an idea of the state-of-art in their field of research but will also help avoid duplication in research, generate new ideas, and help in the creation of more meaningful projects. The collation of the knowledge in the form of a well-analyzed and documented database will also lead to better networking among the teams of researchers from R&D institutions, academia and industry.

This is what the proposed World Science Watch project — a well analyzed and documented database — endeavours to help achieve. The final output will be hundreds of periodic overviews/summaries in different well-chosen theme/sub theme areas along with the important areas. It will not just be a compilation of abstracts but a well-analyzed overview--an indicator to the major researches underway all round the world.

Research focus

- It is proposed to implement the project in phases. To begin with, the initial phase will have around 15 major well-identified theme areas chosen by an apex committee of experts, from the various disciplines of science and technology, e.g. Biotechnology, Molecular Biology, Chemical Science and Technology, Energy, Drugs and Pharmaceuticals, Information Technology, etc. Summaries/overviews will be prepared under a few frontier sub-theme areas under the chosen theme areas, e.g. under the theme area Materials Science we may have Nano Materials, Industrial Catalysts, Polymers and so on.

- In the second and third phases, based on the outcome of the first phase, we may add more theme areas and diversify the sub areas under these, making the coverage more pinpointed and comprehensive.

Envisaged outcomes/outputs

- With the vast amounts of data generated, the *World Science Watch* project is expected to result in the following benefits:
- Access to bibliographic databases and patent databases at par with leading institutions of the world;
- Monitoring of emerging fields and competitors' activities;
- Assessment of performances and trends in research and status of technologies;
- Prevention of duplication in research;
- Identification of patent misappropriation and infringement;
- Identification of patenting/licensing opportunities;
- Most importantly, this project will help in generation of new ideas and lead to a better networking among the teams of researchers from R&D institutions, academia and industry, thereby contributing to the growth of the S&T knowledgebase and technological advancement in the country.

3.2.12.11 R&D in core information technology (*NISCAIR*)

CSIR is making concerted efforts to maximize the use of modern ICT. Under 11th Five Year Plan it is proposed to initiate R&D on core IT. NISCAIR has identified following priority areas for R&D in Information Technology: Next Generation High Performance Data centres, Technology Development in Indian Languages, Database engines, Low cost RFID, E-Agents, Information Security, Network Management, Web-based Applications, Advanced Network Architecture, Vulnerability and Assurance, and Monitoring, Surveillance and Forensics. During the first phase of the plan the focus will be on R&D in Information Security under the PPP model.

Research focus

Information security deals with several different "trust" aspects of information. It applies to all aspects of safeguarding or protecting information or data. Under the present project Information Security will be limited to the following areas: Intrusion Detection System, Cryptography and Cryptanalysis, New ways of encryption, modulation, data-compression and corresponding hardware developments, and Anti-spamming Software.

Crypto systems of higher key lengths are subject to export restrictions. It is required to develop new crypto algorithms for different applications from different perspectives. Fast hardware implementations of crypto systems using Field Programmable Gate Arrays (FPGAs) or Application-Specific Integrated Circuits (ASICs) are needed. Efforts are needed for development of efficient key management, robust encryption systems with small key length and needing small processing power as well as power consumption.

In this background, NISCAIR proposes to undertake research in cryptography and cryptanalysis with Indian as well as with overseas partners.

Envisaged outcomes/outputs

- The benefits of cryptography are well recognized. Encryption can protect communications and stored information from unauthorized access and disclosure. Cryptography protects the privacy by letting you encrypt your emails, documents or any other files, which you do not want unauthorized people to access. Cryptography also enables the use of digital signatures and digital cash. Without it, secured electronic transactions are not possible. This would be useful at the of implementation of E-Procurment in CSIR laboratories. Cryptography also protects our national interest from hostile countries. The possibility of using algorithms / know-how developed for ensuring secure communication between various CSIR offices, could be explored at the end of Phase 1. One of the spin-offs of this project would be that NISCAIR would develop the capability and infrastructure to deliver training and consultancy on cryptography to other CSIR labs/research institutions.
- Initially NISCAIR and its collaborating partners, later on other CSIR labs and Indian industries.Several major IT companies like TCS, Wipro, HCL, etc. are interested for tie-up with NISCAIR for the development of new IT products. NISCAIR is planning to collaborate with these companies and other overseas companies.

3.2.12.12 Creation of national repositories portals & open access journal portal along with citation database (*URDIP)*

Aim of the portal

Develop a portal with local full-text hosting and a citation database for OA journals, which can be far superior to Web of Science (WoS) which does not have full-text availability (WOS was never designed as a full-text citation index database due to its historic limitation). Some surveys have shown that Open access availability of journals improve their impact factor. Indian S&T journals can gain advantage now raiding on this phenomenon. This can be show cased as India's contribution to the promotion of access to OA content.

Envisaged outputs/outcomes

To create: digital library of basic research being conducted in India. This will include papers, theses, reports; network of research communities with a view to share skills and facilities and to provide and web-enabled technical services

NATIONAL FACILITY

3.2.12.13 Development of a state-of-the-art multi-teraflop High Performance Computing (HPC) facility for CSIR(CMMACS)

The projects aims at developing a multi-teraflop High Performance Computing (HPC) facility for CSIR scientists to solve computationally challenging scientific problems for their research work. This system would also have linkages with similar HPC systems in other R&D organizations to share Software/ Hardware resources.

One of the biggest bottlenecks faced by scientists involved in advanced scientific and engineering research is the non availability of access to high performance computing facilities to solve computationally challenging scientific problems. For example, simulations of suspensions containing many particles that can answer several fundamental questions in non equilibrium statistical mechanics, simulations in nanoscience and technology, rational design of photoactive and bioactive molecules, developing novel homogeneous catalysts for organic transformations, study of phase transitions in copolymers, computational fluid dynamics, computational structural mechanics and environmental modelling using coupled models, are some of the areas which require supercomputing facility. Thus, we propose to overcome this by establishing a state-of-the-art, scalable HPC platform with remote access to the scientists of CSIR labs.

Aim of the facility

The main objective of this facility is to enable CSIR scientists to carry out cutting edge research in the frontier areas of science and technology using computational methods and advanced computing.

Envisaged outcomes/outputs

➲ A multi-teraflop scalable HPC platform with a computing power of 30-50 teraflops, 2 petabytes of storage, a rich set of application software in the areas of interest to CSIR labs and high speed communication links with seamless remote computing capabilities. Scientists from CSIR labs will use this facility through remote computing technologies such as web based e-compute, remote login and grid computing to carry out advanced scientific research.

Total Plan budgetary requirement projected for the Sector is Rs. 737 crore

3.2.13 LEATHER

The global leather industry is valued at about US$ 85 billion. Most of the producing countries are developing countries, while developed markets such as the US are major consumers of leather products. The industry is buyer-driven, with producing countries manufacturing in line with specifications, guidelines and technical advice provided by the buyer countries. The Indian leather industry occupies a place of prominence in Indian economy in view of its substantial export earnings, employment generation and growth potential. The export of leather and leather products has increased many folds over the past decades. Whereas the exports in 1956-57 were Rs 280 millions, the figures were increased to Rs 30760 million in 1991-92 and to Rs 106912 million in 2004-05. India has a 2.32 per cent share in the global leather trade and ranks eighth in the world in terms of the country's foreign exchange earnings from the industry. The composition of exports has also been changing, with more and more value added products being exported. In 2004-05, for example, value added finished products constituted around 80 per cent of the total exports from the industry, which was just 7 per cent in 1956-57. India has plans to double its leather exports over the next 5 years. It has been estimated that India has the capacity to meet nearly 10 per cent of global leather requirement.

CSIR's has been engaged to empower the Indian leather sector through generation, development and extension of technologies and participate in the emergence of a knowledge society in leather by way of traceable impact on capacity building. It has further enhanced its position and status in the Indian leather sector as the apex and main advocacy body in leather in assisting the preparation of the Tenth Plan programmes of the industry and delivering a number of viable technology solutions to the leather sector. Department of Industry Policy

Promotion, Govt. of India, has identified CLRI, as an apex leather research institute, to play a major role in making strategies and plan for development of Indian leather industry.

The eleventh plan of CSIR in the area of 'Leather' aims to take further the initiatives and experience obtained during Xth Plan. The proposal is to put the Indian leather sector into the fast track and make networks for overall development of the sector. The programmes proposed for 11 FYP broadly cover the important areas/ issues relevant to total leather sector growth. They include: one suprainstitutional project on atom economy and energy efficiency through thermodynamic insight for first principle led process innovations in leather and footwear and paradigm shifts in chemical to bio processing of leather which aims to augment the overall competency of the lab in developing processes for economy of chemicals/ energy thereby enhancing environmental acceptance of technologies. Three projects are considered under inter-agency mode of implementation involving Collagen based materials for application as health care products, Rationalization of tools, techniques and methodologies for analysis and testing and support to minimization of occupational hazard and Centre for Operation, Management & Policy for Leather Technology for pooling experience and resources of CSIR and other agencies/ leather industry for mutual and societal benefit. Two proposals under networking mode, viz., zero emission research initiative and process and product innovations are proposed which aims at pooling resources and knowledgebase for better and faster delivery of objectives. Creation of two facilities 'Design Centre for Leather Products' and 'Material design and development centre' are proposed which aims at providing superior designs for leather and non-leather products to Indian industry.

SUPRA INSTITUTIONAL PROGRAMMEs

3.2.13.1 Atom economy and energy efficiency through thermodynamic insight for first principle led process innovations in leather and footwear and paradigm shifts in chemical to bio processing of leather (CLRI)

Research focus

- Defining atom economy and energy efficiency in leather and product making
- Determining the atom economy for existing leather process and product making steps
- Development of methodologies for enhancing atom economy in leather processing and product manufacture

Envisaged outcomes/outputs

- Conversion of protein and other matrix present in hides skins into useful products thereby reducing percentage of constituents into the waste stream
- Development of a processing step for leather which is economically viable at the atom level.
- Development of energy efficient production process evolved.

NETWORK PROGRAMMES

3.2.13.2 Zero emission research initiative (*CLRI*, NEERI, IICT, CSMCRI, IMT, IICB)

Research focus

- Consolidation of the leads gained during the tenth plan -Development of cleaner options in leather processing - Enzyme only beam house products and processes: Consolidation of leads gained and cost effective options

- Enzymes in leather processing
- Odor control in tanneries
- Cost effective and viable process and product alternatives complete with novel value addition techniques for surface profiling and texture additionSelf cleaning leather
- Mineral free tanning for soft leathers: garments and gloves

Determine cost effectivity for chemical free beam house operations

- Surface engineering for unusual properties and applications of leather
- High value products from tannery wastes
- Hybrid technologies for end of pipe treatment of tannery wastewaters and secured land fill facilities
- Advanced oxidation and membrane separation methods for tertiary treatment of wastewaters
- Integrated in-plant and end-of-pipe treatment technologies for liquid and solid wastes complete with legal solutions of management of treated wastes in leather sector to suit different investment potentials
- Process innovations based on speciation and microbial bio-technologies for energy efficient degradation of tannery liquid and solid wastes and effective phase sorption and separation methods
- Rational process design and optimization for modernization and improve in plant ecology in tanneries and chemical plants complete with and risk mitigation strategies
- Modeling of bio reactors and alternate methodologies and devices for diffusion controlled processes in leather and allied sector

Envisaged outcomes/outputs

- Development of processes and products leading to IP products
- Development of technologies for ensuring environmental security to the tanning sector

3.2.13.3 Process and product innovations (CLRI, NIFT, New Delhi, NID, Ahmedabad and FDDI, New Delhi)

Research focus

- Product design optimization for footwear and foot care Innovations
- Niche product development for life style product innovations
- Process and product development for Bio degradable leather products complete with Total Life Cycle Analysis
- Advanced technology measures for texture development and surface modifications: including laser ablation
- Advanced materials: for smart functions in shoe construction, light emission, memory management
- Leather: As a feed stock for advanced and smart material design
- Alternative and advanced devices and process control systems for leather, footwear and leather chemicals
- New (Laser) welding systems for footwear construction
- Composites and Smart materials: Energy soaking strategies for controlling thermo mechanical properties, transpiration, elasticity control
- Trend forecasting and product designing and development of footwear for different market segments with a focus on “Value for Money” and IT enabled service outreach

- Interfacing design elements with fabrication technology for lifestyle products based on a combination of leather and judiciously selected alternative materials
- Expanding capacity for research and development on upholstery, glove, ladies handbags with a focus on Value for Money concepts

Envisaged outcomes/outputs

- To gain 7-10 year lead time ahead of the industry.
- A Design Centre for Leather and Products on the lines of ARS, Sutoria in Italy for strengthening and building of design capabilities for the leather sector.

INTERAGENCY PROGRAMMES

3.2.13.4 Collagen based materials for application as health care products(*CLRI,* Sri Ramachandra Medical College, & Research Institute, Chennai, Sri Chitra Tirunal Institute for Medical Sciences & Technology, Trivandrum, Department of Biotechnology, New Delhi, CCMB, ITRC)

Research focus

- Understanding of cellular and molecular events in repair, regeneration in wound healing
- Development of value added 3D collagen scaffolds for tissue engineering and remodeling
- Development and Clinical evaluation of products for applications in health care

Envisaged outcomes/outputs

- Preparation of collagen based second generation products
- 5 patentable products and 3 commercial products.

3.2.13.5 Rationalization of tools, techniques and methodologies for analysis and testing and support to minimization of occupational hazard(*CLRI*, Industry Associations)

Research focus

- Development of reliable eco friendly test methods and standardization of protocols
- Profiling gene expressions in stressed chemical environments

Envisaged outcomes/outputs

- Analysis of hazard and risk factors in industrial units and occupational health and safety in priority areas having industrial relevance.

FACILITY CREATION

3.2.13.6 Design centre for leather products (CLRI)

A Design Centre for Leather and Products is critical to serve the industry needs. The Centre will function on the lines of ARS, Sutoria in Italy and will ensure strengthening and building of design capabilities for the leather sector.

Envisaged outcomes/outputs

- To provide services to leather and leather product industry

3.2.13.7 Material design and development centre (CLRI)

World over, the availability of leather is not commensurate with the demand. Supplementing leather with other materials becomes necessary. The R&D initiatives of the institute will be geared towards meeting the non- leather needs of the sector. It is necessary to create state-of-the-art equipment infrastructure for materials development. Such a center can also work on profit basis if private partnership is entered into for operation and maintenance of the equipment.

Aim of the facility

- Eco designed advanced materials for leather, footwear, photonics and electronics
- Eco benign methodologies for synthesis of organic compounds
- Development of nano composites
- Development of novel polymeric materials for industrial applications
- Directing molecular self assemblies and relating changes in functional behavior of supra molecular systemsDirected and colossal conformational changes in biopolymers and smart products from leather and composites for outerwear
- Predictive tools and techniques for profiling host-guest interactions at reaction surfaces based on molecular modeling and experimental revalidationIonic liquids: As media for reactions involving polar transitions states and as functional templates for entropy controlled reaction paths
- Reaction controls through structural confinement: Selecting mesoporic and open framework systems for supported transition metal catalysts**Envisaged outcomes/outputs**
- The services of the facility will be extended to the industry. Facility for Equipment to be managed and operated by commercial enterprises

Total Plan budgetary requirement projected for the Sector is Rs. 180 crore

3.2.14 METROLOGY

Metrology plays a key role in the technological, industrial and economic development of the country. A national measurement system is essential for growth of nation. It is a base, on which quality management of products and services rests.

In today's competitive environment, it is very important that goods and services produced in the country are comparable in quality to the best available elsewhere in the world. Standardization helps in reducing the product variations, interchangeability of component parts and sub-systems and finally, ensuring its quality and reliability. In India, standardization and quality measurements are ensured through a network of testing and calibration laboratories that prepare and maintain documentary standards of measurements and their traceability to the national & international standards and are responsible for their enforcement in the country.

India is currently on a path of registering an exponential growth in international trade along with China. The opening of economy and its participation in WTO agreements has increased the importance of primary standards of weights and measures and their traceability to international standards. With Government emphasis on increasing its exports, the requirements of the industry for reliable, recognized and traceable precision measurements and calibration work have increased the demand in the accuracy of measurement ranges in all the parameters.

In view of the importance to meet the continually increasing demand of accuracy and improved uncertainties, a major programme entitled "Advancement in Metrology", has been proposed by CSIR in this sector. Under this programme, various projects will be undertaken to be implemented in a network mode. National Physical Laboratory shall drive this network project as nodal laboratory with involvement of several CSIR laboratories as well as laboratories of outside Institutes. Augmentation of calibration facilities and creating new ones would help to maximize the metrology services to Industry.

NETWORK PROGRAMME

3.2.14.1 Advancement in Metrology (NPL)

The techniques of measurements are getting more and more sophisticated with the advance of technology and today, the latest scientific concepts are being utilised in metrology. There is need to ensure high quality measurement as well as the maintenance and the traceability of analytical measurements to national/international measurement system (SI unit) in order to fulfill the mandatory requirement of quality systems (ISO/IEC guide 17025) and of the National Accreditation Board for Testing and Calibration Laboratories. It is clear that the best route for any economy to prosper in the global market place is to improve the international competitiveness of its manufacturing industry. This certainly requires better products at lower prices, however, even that is not enough – the potential customer also needs to be convinced of the quality and compliance of the product, which must be proven by reliable test reports and conformity assessments.

In the proposed network project, efforts will be made to further strengthen different and emerging areas of Metrology and bring together to enhance the range of calibration capability and improving the uncertainty of measurement in areas of Physico-Mechanical Standards Activities and Electrical and Electronic Standards Activities. Further, the areas of Certified Reference Materials, Materials Metrology, Nano Metrology would be expanded and strengthened. Networking of the CSIR laboratories and outside agencies will be made and their traceability to National standards maintained at NPL will be established. Thus different laboratories will be able to cater to the needs of the industries in their region.

Research focus

The programme will be carried out through six specific tasks .Each of following tasks will cover the following aspects for the "Advancement of Metrology" to bring it at par with the international status and to meet the demands of the Industries.

Task I: The up-gradation of base units

Task II: Improvement of the Apex calibration capabilities

Task III: Nano metrology by establishing the calibration facilities at nano-scale, especially for the calibration of standards such as step height, line width, surface profile.

Task IV: Metrology in Chemistry (MiC) by establishing and realizing seventh SI base unit.

Task V: Materials Metrology

Task VI: Certified Reference Materials by strengthening the existing satellite groups and create new groups particularly in the areas of food, drugs, fine chemicals, clinical and ultrasonic velocity.

In order to carry out the above tasks an *Environment Controlled Metrology Building* would be set up at NPL under this programme.

Envisaged outputs/outcomes

The expected outputs/outcomes at the end of the XI Five-Year plan will have both direct and indirect impact and benefit to the society. These outcomes are to cope with the changing and increasing requirements of measurements, calibration and standards with the rapid advancement in technology and provide related services to the industry. NPL is a signatory of Mutual Recognition Arrangement (MRA) drawn by the International Committee for Weights and Measures (CIPM). NPL will have to demonstrate the technological capabilities and competence in the international trade arena to derive the international credibility and the global acceptance of the measurements rendered by NPL.

The detail layout of outputs for each tasks are given below:

Task I & Task II

Force and Torque Standard

- Establish the facilities to realize force in mili-Newton, micro- and nano- Newton.
- Develop economical and accurate load cells and load cell calibrators.
- Improve performance and extend the range of already transferred patented technology of force transducers to the industry.
- Design and develop the transfer standards in the field of force and torque.
- Continue to provide traceability to neighboring countries including Nepal, Bangladesh, Sri Lanka, Oman, Kuwait, Saudi Arabia, etc.

Mass Standard

- Replace of existing mass measurement instruments (20 year old) with better measurement capability.
- Improve the apex level calibration capabilities.
- Optical Radiation Standard
- Establish detector based primary standard of radiometry and photometry bringing the measurement to international level through the Cryogenic Radiometer.
- Establish primary diffuse reflectance standard with better measurement uncertainty.
- Establish the absolute scale of spectral irradiance with the Blackbody
- Establish the setup for spectral irradiance with improved Luminous intensity scale uncertainty.

Length Standard

- Establish Frequency Comb for the direct realization of unit Meter, and absolute measurement of frequency as already adopted in UK, Russia, US, Japan, Germany, Canada, Austria, Australia, Korea etc.
- Upgrade the facility for measurement of surface roughness and extend the interferometric measurement of length upto 100mm with improved uncertainty.

Pressure & Vacuum

- Upgrade the standards with improved measurement uncertainty of pressure and vacuum standard to maintain the existing international status of NPL.
- Establishment and up gradation of the high pressure facility using Laser Raman Spectroscopy

Ultrasonic facility

- Upgradation of existing set up of ultrasonic measurement system to achieve the uncertainty level at par with the international level and replacement of 20-years old set up to calibrate extremely complex medical equipments.
- Help the Indian manufacturers to export their ultrasonic medical equipment to Western and American countries.

Temperature and Humidity

- Establish International Temperature Scale at par with other NMIs.
- Establish the facility for calibration of Hygrometers in the lower humidity range/dewpoint (i.e. -50^{0}C dew point to + 20^{0}C dew point)
- Establish primary standard of humidity.
- Josephson Voltage Standard
- Procure programmable JVS standard.
- The portable Josephson Voltage Standard to be used for direct international inter-comparison (array to array comparison).
- Chip, an essential component of the Josephson Voltage Standard (JVS) system for calibration of Sneer Reference Standard (Sneer cells 1.018V & 10V).
- LF and HF High Voltage, Current and Power
- Up gradation of Primary Standard of LF voltage and current in the frequency range of 10 Hz to 1MHz, to be at par with the advance level NMI in the world.

- Establishment of standards for very low frequency voltage amplitude in the frequency range 1 MHz to 10 Hz. (Mostly required by industries design establishments in sectors such as structures).
- Upgradation of the frequency range of RF power primary standards and calibration facilities to 40 GHz from 18 GHz, at par with International level.
- Establishment of standards of RF Noise in the frequency range up to 40 GHz.
- Establishment of standards and measurement facilities for RF field up to 40 GHz for measurement of radiation/leakage (EMC/EMI) including antenna parameters. (4 and 5 deliverables are required by Space Research, Communication Industry and Defense R&D and production).
- LF and HF Impedance
- Extension of frequency range for calibration from 20 Hz to 10 kHz in LF and HF Impedance Standards.
- Improve the measurement capability at High Frequencies in the range of from 10 kHz to 250 MHz.
- DC High Voltage
- Attain measurement uncertainty of 10 ppm of DC High Voltage sources.
- AC High Current and High Voltage
- Establish "C and tanδ" measurement facility.
- AC Power & Energy
- Establish primary standard of AC Power and Energy at par with International level of 10-20 ppm.
- Establish accurate measurement of DC output of primary standard and watt converter for inter-comparison.
- Establish Shock testing and Impulse voltage testing as per IEC standard required by mobile calibration laboratories.
- Replacement of old calibration bench (source with reference standard)

Time and Frequency

- Improve the uncertainty of Time scale to better than 5ns to be at par with leading time keeping laboratories.
- Establish an improved time link with Japan and Europe through TWSTFT to improve link uncertainty to ~2ns.
- Develop Laser Cooled Cesium Fountain Standard which is the state-of-the-art as the best frequency source (developed in many laboratories) but not commercially available.
- RF Attenuation
- The traceability chain for attenuation measurement will be established.
- Magnetic Standard
- Introduce lower and higher range of Magnetic field.

Task III

- Provide the Indian industries, R&D organizations etc. (involved in semiconductor fabrication) traceable calibration at par with international level
- Calibration of standards such as step height, line width, surface profile which is widely used by the R&D institutions using AFM, SEM, TEM etc. for doing measurements at nano-scales

Task IV

- Realization of SI base unit, the amount of substance 'mole' national standards of measurements.
- Establishing the equivalence of the Indian national standards with the international standards for SI mole in the areas of organic/ inorganic/ gas/ electrochemical/ surface & bio analysis and in all aspects of life.
- Creating MiC network of laboratories, for development and validation of MiC procedures, training of manpower, linkages with Certified Reference Materials (CRM) programme.

Task V

Establish internationally accepted test methods for materials characterization for following parameters:

- Structural measurements (X-ray related)
- Micrographic measurements (SEM, TEM and AFM)
- Magnetic measurements (EPR etc.)
- Surface & Interface composition (SIMS etc.)
- Chemical composition / impurity / dopant (AAS, ICPMS, EPR, IR etc.)

- Certified Reference Materials: α- alumina & LaB_6 (for X-ray intensity), Si-powder (for lattice spacing), gold nano particles (for TEM resolution) and EPR powder sample (for spin concentration) measurements.

Task VI

- CRMs prepared under this activity will be used in all the sector of science and technology and industry for quality control.
- Various satellite groups will produce at least 40 new CRMs and each group will participate in international key comparison programme for traceability.

Total Plan budgetary requirement projected for the Sector is Rs. 270 crore

3.2.15 RURAL DEVELOPMENT, WEAKER SECTIONS, WOMEN & NORTH-EAST

CSIR recognizes that S&T inputs could significantly contribute to improve the quality of rural India. Sustainable development of rural areas needs to be linked to the development of people. This would call for significant technological interventions in many areas include drinking water, shelter, energy, environment, health, food, farm and non-farm sectors.

The framers of the Constitution took note of the fact that certain communities in the country were suffering from extreme social, educational and economic backwardness arising out of age-old practice of untouchability and certain others on account of primitive agricultural practices, lack of infrastructure facilities and geographical isolation, and who need special consideration for safeguarding their interests and for their accelerated socio-economic development. These communities were notified as Scheduled Castes and Scheduled Tribes. With a view to provide safeguards against the exploitation of SCs & STs and to promote and protect their social, educational, economic and cultural interests, special provisions were made in the Constitution. Science & technology has to play a crucial role in development of these communities as well.

The Northeastern states of India, being under developed demands special attention. The Northeast region is divided into discrete plains encompassed within hills, with a number of agro-climatic zones within them. The region is bountifully endowed with bio-diversity, hydro potential, oil and gas, coal, limestone and forest wealth. Science & Technology can provide ideal technological inputs to produce and process a whole range of plantation crops, spices, fruit and vegetables, flowers and herbs, much of which could be processed and exported to the rest of the country and worldwide. CSIR in the Eleventh Plan would evolve specific programmes and projects to address S&T related developmental issues which would become harbinger for the speedy development of North-East regions.

Council of Scientific & Industrial Research, India commitment to link its S&T support system to the Rural Development initiatives of the country has been total. CSIR is driven by an urge to play a technology fountainhead for industrial growth. Within its overall mandate, CSIR has prepared a plan for its own orientation to rural development programs in some select areas of focus.

Council of Scientific & Industrial Research (CSIR), India aims join hands with various government departments and ministries towards meeting the commitment to leverage its relevant knowledge base for the benefit of rural sector, north east region and weaker sections of the society. CSIR has also established new linkages and partnerships by providing technological support for basic human needs of the people living in rural India in key S&T areas of strength.

Approach for the Eleventh Five Year Plan involves the commitment of CSIR in S&T efforts leading to sustainable development of rural India needs a new orientation of the agency to spread the effects of technology led development of India. The reorientation is proposed in its methods and approaches to link S&T outputs with users in rural India. The orientation is to build focus and momentum and deliver through networks. It is a demand driven approach. A project mode action plan is preferred for speedy delivery of outputs. A programme orientation to the development and dissemination of suitable technologies of the right sizing of scales for applications in rural India is the chosen path. Envisioned modes of delivery shall include the development of both internal and external linkages, which may lead to partnership between the agency and the user target in rural India.

Action oriented research project and classical technology transfer project would be given more importance. A budget of Rs. 10.00 crore is recommended for the youth and rural transformation initiative so that the specific problems identified from the field interactions are posed to the students for taking these up as the projects in the final undergraduate or at the postgraduate outsourcing process (TOP) can be started from EFYP in every laboratory.

Partnership with organizations such as NIF, Ministries of Rural Development, Social Welfare, Agriculture etc. would be strengthened. A budget of Rs, 20.00 crore is recommended for the same.

The segments chosen under the above clearly reflects on the approach of CSIR for holistic rural development. The need to link S&T support system not only with the rural development initiatives of the country, but would also address the **women specific issues,**

development of SCs/STs and North East region. Focus would be given to **eradication of social and economical injustice as well as backwardness**. Knowledge system partnership, currently lacking, will be strengthened for economic upliftment. Attempts would be made to address S&T issues towards recalibrate CSIR technologies and refocused for user participation, which will eventually become the MANTRA for Eleventh Fiver Year Plan (EFYP). Goals at different levels like local, regional, state, national will be spelled out clearly. In EFYP rural technology projects would aim towards **rural to high-end applications**. The best-established examples are **carcass utilization**, where carcass management is done at rural levels whereas **leather** is exported after high-end value addition. Similar are the examples of food **processing** and **natural fiber composites**. These are the projects, which will generate **enormous employment and wealth to the rural masses** of the country. Innovative gadgets can be linked to rural areas to raise the standard of living and the programs should include technology, training, maintenance, loan facility and marketing. **Popularization and dissemination** would also be given due importance in EFYP for the outreach of appropriate technologies. Popularization modes like **publication of Journal of Rural Technology**; **Establishing rural galleries**; Organization of **workshops/meetings/training/awareness programs/gram mela** etc. would be given substantial importance and support.

PROJECTS

3.2.15.1 BUILDING MATERIALS & ROADS

(i) Sisal- potentials for rural development and green technologies (RRL-Bhopal CBRI, RRL-Tiruvananthapuram, RRL-Jorhat, NCL, and CLRI)

The tremendous potential of sisal as a resource not so far been exploited for value addition and as a source of employment generation in rural and semi-urban sectors. Investigations indicate that there is a great potential for the development of sisal based technologies for engineering and rural applications.

Sisal leaves yield quality fibre, which is utilized for conventional purposes like ropes, anchors, cordage and handicrafts. It can be utilized for the development of composites for applications in building materials, automobiles, railways, boats, packaging, geotextiles etc.

Since sisal is a xerophyte, its cultivation in major parts of India is relatively easy and involves least water and crop management during its survival period of about 10 years. They can be raised along the bunds, hedges, forest and wastelands for soil conservation. Once established, an assured production of about 2.5 tonnes of fiber per hectare per annum is possible for 6 - 8 years. Presently sisal plantations and related activities are unorganized and localized mostly in rural and tribal areas. Sisal plantation activity has the annual employment potential of about 100 man-days per hectare.

It is understandable that there is a huge quantity of sisal waste (95% of the leaves by weight) which can be effectively utilized for composting, vermicomposting and extracting other valuable products. The pilot scale demonstrations show that it is a valuable feedstock for biogas plants to cater to the local and rural energy requirements. Sisal leaves are known to contain wax (0.38%) and hecogenin (0.10%), a sapogenin steroid with variety of pharmaceutical applications.

Research focus

Development of technology and machinery for continuous sisal fibre extraction (Raspador) and sisal yarn making (Spinning) and fabric manufacturing (Looms); Developing various handicrafts from sisal fibre and vermicompost technology using sisal waste for rural employment generation; Product development for applications in building materials asbestos free roofing sheets, for low cost rural housing, instant houses for natural calamities prone zones, automotives, railways, geo-textiles, leather composites, fishing boats, acoustic / noise barrier and thermal resistant materials; Development of biodegradable polymers; Training of targeted groups viz. individuals / rural masses (women, SCs/ STs, Northeast region, weaker sections in particular), NGOs, entrepreneurs in various aspects of sisal technologies; Improvement of the quality of life of rural mass through increased income generation by developing sisal based rural technologies; Mission mode programme on establishment of Center of Excellence' for the development of cost effective sisal fiber technologies.

Envisaged outcomes/outputs

➲ Under Public Goods**:** Automobiles (Trim parts, Door panels, Brake liners, brake shoe, Seat cushions, Package tray; Railways (Doors, Luggage racks, Floor / Roof panels, Berth & Chair, Backings, Interior panels & Partitions, Interior furnishing & Seating): Under Private Goods:Building Materials (Door, partitions, Flooring tiles, panels, Roofing elements, Furniture and interiors): Under Strategic Goods**:** Asbestos substitutes, instant houses for disaster prone areas, Acoustic materials: Under Social Goods**:** Handi craft items, ropes and cordage, geo textile, packaging materials, leather composites, vermicompost

(ii) Pavement options for rural road construction in BC soil areas (CRRI, RRL-Bhopal)

Black cotton (BC) soils extend over one-third of the total area of our country. BC soils have been formed as a result of chemical decomposition/weathering process of basaltic and trap rocks of Deccan plateau. Satisfactory performance of roads and other structures built over these expansive soils is of paramount importance. Road construction as well as performance of pavements in BC soil areas has not been very encouraging experience in our country, since the recurring cost of maintenance of these roads has been of a high order. It is proposed to take up comprehensive study of rural road construction in BC soil areas in association with Madhya Pradesh Rural Roads Development Authority and Regional Research Laboratory, Bhopal.

Research focus

Studying the present practices for rural road construction in BC soil areas and identifying problems/failure modes associated with it; pilot project on construction of rural road by adopting different techniques (stabilization, use of geotextile, etc.); Performance evaluation of the pilot project road.

Envisaged outcomes/ outputs

➲ Detailed characterization of BC soil in the identified road stretch; design of rural road pavement cross section by adopting various techniques- lime stabilization, use of synthetic geotextiles, reinforced base/ sub-base courses, etc. construction of the identified road stretch and monitoring its performance

3.2.15. 2 FOOD TECHNOLOGIES

(i) Herbal wine production (IHBT)

Research focus

Training rural women for quality herbal wine production; Facilitating small scale industry on herbal wine production

Envisaged outcomes/outputs

➲ Demonstration on wine making technology at 3 selected places utilizing the local fruits viz., *Citrus karna*, *Emblica officinalis*, and *Pyrus pashia* in Kangra and Chamba districts; wine production units of 100 liter capacity will be established in these districts; *Mahila mandals*, women NGOs and other self help groups will be involved in the activity

(ii) Production and recovery of bio-flavors from damaged cull fruits and biomass (NEERI)

Research focus

Assessment of physico-chemical and microbiological characteristics of damaged cull fruits and wastes generated from fruit and vegetable processing units; screening and selection of strains of microorganisms having potential to produce bio-flavours using biomass produced from damaged cull fruits and vegetables and also wastes from fruit and vegetable processing units; optimization of process parameters for maximum production of bio-flavour compounds using specific microorganisms; selection of process parameters for extraction and concentration of bio-flavours from the fermented broth; materials and energy balance for the developed process through bench scale experimentation; development of a suitable process for mineralization and composting of residual waste after fermentation and recovery of bio-flavours from wastes

Envisaged outcomes/outputs

➲ Improvement in economical status of rural community; publications; patents; specifications for commercial acceptability; techno-economic feasibility; tie up with the industry for commercial exploitation

(iii) Tea farm mechanization (IHBT)

Research focus

Demonstration-cum-training for capacity building of rural youths for mechanical pruning, skiffing and leaf harvesting in tea plantation.

Envisaged outcomes/outputs

➲ Capacity building of rural youths for mechanical pruning, skiffing and leaf harvesting in tea plantation

(iv) Tea advisory services for production of quality tea (IHBT)

Research focus

Demonstration of agro-practices for production of quality tea; Assessment of economics of production of quality tea

Envisaged outcomes/outputs

- agro-practices for production of quality tea.

(v) Development of power operated weeder (RRL-Bhubaneshwar)

Research focus

Development of cost effective efficient technologies for sustainable rural development

Envisaged outcomes/outputs

- Compact power-operated weeder, operated by small kerosene engine, which can remove the grass, weeds etc effectively from the agricultural land with less effort & fuel consumption during cultivation of different crops. This can reduce manual labour and improve yield in agriculture

(vi) Development of downsized technology for removal of wax from sunflower & peanut oil appropriate for farmers (RRL-Bhubaneshwar)

Research focus

Development of cost effective efficient technologies for sustainable rural development

Envisaged outcomes/outputs

- The downsized mechanical / chemical low cost de-waxing technology can remove the wax from sunflower and peanut oil by the farmers, so as to preserve the edible oils for a long period without spoiling in rural sector. This will help production & marketing of edible oils by the farmers, instead of selling the oil seeds to the oil processing industries.

(vii) Cottage scale processing units of coconut (RRL-Tvm.)

Research focus

Cottage scale processing of agricultural products through natural convection driers.

Envisaged outcomes/outputs

- Suitably modified versions of rrlt-nc driers for the materials and products depending upon specific localized need; suitable cost effective drying system integrating the different hot air generation systems using solar, bio gas, agri.waste materials, LPG; training and awareness in the systematic drying and preservation of vegetables and fruits and other agricultural products to the rural especially women population.

3.2.15.3 DRINKING WATER

(i) Development of low cost water filter devices, made from locally available materials, for removal of Turbidity, Iron, Fluoride and microorganisms from raw water. (RRL-Bhubaneshwar)

Research focus

Development of low cost water filter devices, made from locally available materials, for removal of turbidity, iron, fluoride and microorganisms from raw water.

Envisaged outcomes/outputs

- Improved TERAFIL a cheap and most efficient domestic filtration and treatment device to obtain safe & clean drinking water in rural sector.

(ii) Development of TERAFIL (clay filter disc) assisted tube well hand pump for supply of Iron safe ground water (RRL-Bhubaneshwar).

Research focus

Development of TERAFIL (clay filter disc) assisted tube well hand pump for supply of Iron safe ground water.

Envisaged outcomes/outputs:

- A gadget containing TERAFIL to be implemented in the tube well hand pumps for obtaining iron safe drinking water at the desirable flow rate.

(iii) Decision support system for sustainable watershed development and management (RRL-Bhopal)

Research focus

To assess the problems associated with the watershed through peoples participation; establish monitoring network for hydrometeorological, physical and process related parameters; collect the data, implement GIS and hydrological modelling on watershed hydrology; develop decision support system for sustainable management of milli-watersheds; planning, designing and implementation of milli – watershed; dissemination of developed decision support system tool to state line departments, local, technical NGOs, PIAs etc.

Envisaged outcomes/outputs

- Mitigation of the effect of drought; Supply of drinking water through maximisation of water conservation; minimisation of environmental degradation; ensure people's participation & involvement in programme design and development; ensure gender-quality in all programmes and decision making process by encouraging women's participation; enhancement in agricultural production. ; encouragement in social forestry; creation of self Help Groups activities ; continuous employment generation.

3.2.15.4 LEATHER

(i) Development and demonstration of technology for better recovery and utilization of fallen animal carcasses (CLRI)

Research focus

- Development of suitable technologies/techniques for recovery and use of carcass by products; preparation of appropriate models for implementation; demonstration at field level.
- Envisaged outcomes/outputs
- Full and better utilization of animal resource; quality hides/skins for leather industry; gainful employment for traditional artisans; clean environment in the rural surroundings

(ii) Development of appropriate technology /techniques and demonstrations for improving the rural tanning (CLRI)

Research focus

Development of suitable technologies/techniques for rural tanning; identification of potential locations; demonstration at field level

Envisaged outcomes/outputs

- Improving the quality of leather; enhancing the financial returns; gainful employment for traditional artisans

(iii) Development /demonstration of technologies for strengthening rural leather sector (CLRI)

Research focus

Development of technologies/techniques suitable to micro enterprises; imparting design knowledge; demonstration at field level

Envisaged outcomes/outputs

- Improving the quality and design of footwear; enhancing the financial returns ; gainful employment for traditional artisans

(iv) Development of novel leather products based on ethnic designs (CLRI)

Research focus

- Capturing the rich ethnic designs of India; development of novelty leather articles; demonstration at field level

Envisaged outcomes/outputs

- Making novel handmade artistic leather items for premium markets; enhancing the value realization; gainful employment for traditional artisans

3.2.15.5 HANDICRAFTS & CERAMICS

(i) Value added ceramic products using locally available raw materials and harnessing of biomass energy for rural development (CGCRI)

Research focus

Economic development of rural India through introduction of a new generation of rural pottery activity; development of utility ceramic products of superior quality at a lower cost through gainful utilization of abundantly available local red burning clays and inferior quality china clays; dissemination of technology among prospective entrepreneurs in rural areas through establishment of demonstration-cum-common facility centres at different locations and conduction of training programmes.

Envisaged outcomes/outputs:

- Products with superior properties and market potentiality;Utilization of locally available raw materials including bio-mass, which may be a waste product in certain areas of the country; This will lead to rural industrialization and employment generation among the rural people including the backward and weaker sections of the society.

(ii) Development of novel ceramics for rural sector through modifications involving advanced materials technology (RRL-Tvm.)

Research focus

Development of terra cotta like building components from industrial wastes and non clay materials; nano metal luster for products made by potters; self cleaning, anti algal and anti bacterial terracotta products like water jugs, terra cotta cups, clay building products; natural fiber based composite building components and hollow panels

Envisaged outcomes/outputs

- Four technologies which will be implemented in the rural sector by effective modification of the present facilities for value addition; setting up of three or more demonstration centers in rural clusters jointly with the NGOs for the new processes and products; impart regular training and dissemination of information on modern approaches for materials processing and extend the same through the NGOs.

(iii) Stone based handicrafts and decorative items (RRL-Bhopal)

Many parts of Central India are endowed with plenty of semi-precious stones like Agate, Sand stones, Opal, Granite etc. Preliminary investigations indicate that they have great potential by processing them and making utility items. The new project aims at development and training on the advanced methods of agate stone cutting, grinding, polishing, drilling and making value addition to the stones by making attractive and readily marketable handicrafts, which have tremendous export potential to the rural masses. This training to the rural masses will create employment potential and generate income. The activities include training rural masses in various representative locations, where the semi-precious stones is available on the above aspects in Central India. This will lead to improve the quality of life of rural mass specially women community.

Research focus

Development of processes and machinery for the processing of semi-precious stones like Agate available in Central India for making handicrafts and decorative items; training of targeted groups viz. selective master trainers, NGOs, and rural masses in a phased manner on different aspects of semi-precious stone based handicrafts in different locations in Central India; creating market potential for the semi-precious stone handicrafts and decorative items made by the trained rural people, by the introduction of various attractive and marketable designs; employment generation and rural upliftment through semi-precious stone based handicrafts

Envisaged outcomes/outputs

- Various decorative and utility artifacts like Lamp shades, fish aquarium, dressing table, paper weights, trays, furniture, gifts and other novelty items; training of rural masses on stone based handicrafts; employment generation in rural areas; creation of marketing and export potential, employment generation and rural upliftment

3.2.15.6 MEDICINAL & AROMATIC PLANTS (IHBT)

(i) Design and development of mobile essential oil extraction units (IHBT)

Research focus

Demonstration on essential oil distillation in remote areas of Chamba and Kinnaur districts

Envisaged outcomes/outputs:

- To popularize cultivation and processing technique of aromatic crops in remote mountain regions, a mobile distillation unit will be designed and demonstrated to the growers in associations with DDP Pooh, KVK Chamba and NGOs

(ii) Training on virus-tested planting material production technology of apple, plum and cherry

Research focus

Establishment of nurseries for raising virus-tested apple, plum and cherry plants at University of Horticulture & Forestry, Solan; .extension of area under apple, plum and cherry by providing virus-tested nucleus planting stock.

(iii) Demonstration of curcuma and hedychium cultivation in agro-forestry system

Research focus

Total of 20 ha of forest area will be brought under *Curcuma aromatica* and *Hedychium spicatum* in agro-forestry farming system in Palampur forest area.

(iv) Utilization of locally available plant raw materials for fetching higher prices

Research focus

Wild growing plant species such as *karripatta* (*Murray koningii*), *vaccha* (*Acorus calamus*) and wild apricot (*Prunes* species) will be taken for value addition by the rural people; IHBT will create necessary infrastructure so that technological intervention is possible to enhance value (seed oil, essential oil etc.) of naturally occurring plant wealth; Utilization of waste from processing units like citrus peels, apple pomace for value addition.

(v) Promotion and utilization of bamboos

Research focus

Mass scale plantation of bamboos on marginal and degraded lands; demonstration and training on bamboo charcoal production; establishment of units for conversion of bamboo to activated charcoal; demonstration for production of other utility products from bamboo; trainings on bamboo propagation methods.

(vi) Promoting large-scale cultivation of medicinal, aromatic and other high valued crops

Research focus

Establishment of sustainable community based aromatic & medicinal plant product units in Pooh (Kinnaur) and Chamba district of Himachal Pradesh; to provide technology backup and training for production, post-harvest management, processing, and quality control regarding the target crops; extension of crops for flavours, sweeteners, biopesticides and dyes.

(vii) Transfer of cut-flower and virus-tested planting material production technologies

Research focus

Trainings on virus-tested lilium bulbs production through tissue culture to rural women for self-employment; trainings to unemployed youths for production of commercial size bulbs from virus-tested tissue cultured raised micro bulbs; setting up of demonstration plots for transfer of agro-technologies for cut-flower and planting material production in Kangra and Mandi districts.

(viii) Survey, collection, identification and exploration of potential medicinal, aromatic and economic plants of NE region

Systematic evaluation of the huge and scientifically almost untouched flora of Arunachal Pradesh necessitates quick recognition of medicinal and economic plants for developing agrotechnology and exploring new or better source of chemicals. The developed agrotechnology will not only generate knowledge but also will help in extending the organized cultivation of selected medicinal and economic plants for the socio-economic uplift of the rural sector of Arunachal Pradesh in particular and the NE region in general. This will contribute to the economy of the ethnic population of the state and help in development of agro-based industries appropriate to the rural area of the region.

Arunachal Pradesh, where transport and communication are the major bottleneck, agro-based industries having low volume high cost product may be a good proposition for the economic development of the rural sector. The organized cultivation of medicinal and other economic plants having high value and low volume win generate self-employment opportunities of the ST population of the state. Moreover, the genuineness and assured availability of medicinal herb will be maintained

Research focus

Development of process for extraction of fibres from suitable plant species and utilization of such fibres in making various value added products; development of technology for making twines and yarns, particle and fibre boards, paper and boards different grades of pulp for making handmade paper, boards, newsprint etc. ; durvey, screening and collection of the dye yielding plants and selection of suitable species depending upon their availability and quality of dye component; development of process for extraction of dyes from various parts of the plants and standardization of process for extraction; evaluation of chemical configuration and characterization of the extracted dyes components. study of the fastness properties on fabrics like cotton, silk, wool etc.; preparation of technology package for extraction and possible utilization.

Envisaged outcomes/outputs

➲ Employment generation and socio-economic development of the people of N-E region particularly in rural areas; organized cultivation of medicinal, aromatic and other economic plants will develop the economy of rural ST population of Arunachal Pradesh, generate employment opportunities and conserve the natural floristic elements of the state.

3.2.15.7 RURAL ENERGY

(i) Development of low cost biomass fired incinerator for medical wastes in rural sector (RRL-Bhub)

Research focus

Efficient utilization of liquid, gaseous and biomass fuel in domestic and rural sector.

Envisaged outcomes/outputs:

- The Biomass fired incinerator can burn and destroy medical wastes at 1100°C to reduce pollution & contamination in rural hospitals at less expenditure. The incinerator will be affordable even by small hospitals

(ii) Development of low cost solar assisted cold storage for vegetables (RRL-Bhub)

Envisaged outcomes/outputs:

The low cost solar assisted cold storage will work without electricity at any place, which can preserve a variety of vegetables at a low temperature. The proposed cold storage can be made with cheap materials to reduce its cost and operation.

(iii) Development of Integrated Biomass Energy Technology for alternative power generation in selected villages of Madhya Pradesh (RRL-Bhopal)

Research focus

Design of cost effective multi-feed (Biomass, Bagasse,wood waste) bioreactor and gas collection system for biogas (methane) generation; design of process package for purification of biogas to upgrade to natural gas standards by absorption methods viz removal of CO_2 and Sulphur recovery; combined heat and power generation (CHP) from energy recovery; simulation of energy recovery process by using mathematical models for 125 KVA / 500 KVA power generation; optimisation of biogas power generation cost to a level of 50 to 60 % less than the conventional power generation cost.

Envisaged outcomes/outputs:

- Developing cost effective Multi-feed bioreactor for biogas (methane) generation; developing potential economically viable / cost effective renewable energy resource from rural biomass and agricultural waste; to replace purchased energy for electricity, heating or cooling in rural villages; developing alternative profitable biogas fuel for internal combustion (IC) engine or gas turbine driven generator to produce electricity; recovering waste heat from internal combustion (IC) engine which can be utilized for producing hot water for farm use or hot water for digester heating, thereby improving the overall energy efficiency of the system; Improve the process controls for specific digester designs, tailor digester design for specific type of organic wastes, and integrate the process with other waste treatment technologies; to provide segregation methodology for processing and handling of potential digester feed material; Generate rural self sufficiency, reduced deforestation and dependency on imported fossil fuels in rural areas; community/ society concerning human development for economic growth due to biomass power generation and utilization; providing inexpensive biomass fertilizer to increase rural agriculture production; disposal of all rural organic biomass related waste reducing severe public health problems in rural areas.

(iv) Development and Evalluation of fuel-efficient cooking stoves, lighting appliances and other combustion system, fuel saving devices etc. for domestic and rural application.

Research focus

Up gradation of existing development/evaluation facility. Evaluation of cooking, lighting appliances and other combustion system, fuel saving devices etc. for domestic and rural application. efficient utilization of liquid, gaseous and biomass fuel in domestic and rural sector.

Envisaged outcomes/outputs

- Value addition and further development of rural technology innovation in collaboration with NIF; fuel conservation and reduced atmospheric pollution; Welfare of rural masses by providing them fuel efficient combustion system technologies suitable to rural environment.

3.2.15.8 POPULARIZATION

(i) Dissemination of Cost Effective, Durable, Disaster-resistant Rural Building Materials and Construction Technologies (CBRI)

Research focus

Organisation of dissemination and training activities to extend R&D benefits for: promotion of cost effective, durable disaster-resistant technologies in different regions of the country for rural development; competence building of professionals and training of skilled/semi-skilled construction workers for mass scale adoption of rural technologies and creating newer employment opportunities.

Envisaged outcomes/outputs:

- Organization of 4 to 5 dissemination/ training programmes in different regions of the country; mass awareness of CSIR technologies and processes through exhibitions, media, demonstrations & training.

(ii) Dissemination and showcasing of CSIR Rural Technologies (RRL-Bhopal)

CSIR Rural Action Program (RAP) committee made very important recommendations which include periodic publication of a research journal on Rural Technology and printing of draft plan on orientation of CSIR Rural Development Programs. The other major initiatives recommended by the committee were to establish CSIR Rural Technology gallery to showcase various CSIR developed rural technology models.

RRL, Bhopal has brought out eight issues Vol I (1-6); Vol. 2 (1-2)) of the journal and distributed the same as gratis copies to around 1000 subscribers for wide publicity and dissemination. The journal has received good attention among rural development institutes/organizations, NGO`s and smaller communities. The future plans include making the journal international and acquiring impact factor.

The CSIR draft plan “Making Technology work for Rural India” has been published and distributed. The Hindi version of the same has to be printed for its outreach among smaller communities.

Research focus

Quarterly publication of Journal of Rural Technology; distribution of CSIR draft plan “Making Technology work for Rural India”; establishment of Rural Galleries at different zones to showcase CSIR Rural Technologies.

Envisaged outcomes/outputs:

- Journal of Rural Technology; CSIR draft Plan on Rural Development; 5 Rural Galleries; workshops/meetings/training/awareness programs/gram mela; annual workshop on rural development; Dedicated website.

3.2.15.9 TECHNOLOGY ABSORPTION

(i) Transfer and dissemination of the proven rural technologies of RRL-Bhubaneswar in different states for sustainable rural development (RRL-Bhub.)

Research focus

Transfer and dissemination of the proven rural technologies of RRL-Bhubaneswar in different states for sustainable rural development.

Envisaged outcomes/outputs:

- Expected impacts can be made after five years of dissemination of the Rural technologies in the country; conservation of fuels: Rs. 500/- crores per year; reduction of pollution: 3.0 million ton green house gas/ year; increase in productivity in agriculture / cottage industries more than Rs.500/- crores per year; Supply of drinking water: 200 million liters water/ year; micro/tiny/cottage industries: more than 10,000 units; employment generation: more than 10.0 lakhs man days /year.

(ii) Products and Technologies for Rural Development (CSMCRI)

Research focus

Development of cottage industries for gypsum based products; improving salt quality for the upliftment of agarias; superior writing chalk; seaweed farming and value addition as gainful employment and alternative livelihood for costal fisher folk ; development and implementation of hybridized medium temperature (100 to 200^{o}C) solar thermal energy systems with a thermal rating of 1 to 10 kW and solar photovoltaic current driven controls for rural applications; village friendly biodiesel technology; portable units for oxygen enrichment of air suited to rural population; waste Heat recovery for thermal desalination in remote location such as little Runn of Kutch; ion exchange resin based Water purification system for arsenic and fluoride removal

Envisaged outcomes/outputs:

- Technologies to provide superior products like writing chalk for schools, potable water for villages, medical oxygen for rural folks, energy in rural set-up

(iii) Green Technologies for Upliftment of Rural Economy, Health and Environment (NBRI)

Research focus

Promoting use of locally available natural resources for income generation: *Acacia nilotica* pods and *Trapa natans* fruit coat for extraction of phyto-nutrients of economic importance; demonstrating and popularizing utilization of *Cassia tora*, *Cassia occidentalis* and *Sesbania aculeata* for seed gums and *ex-situ* green manuring; popularizing the use of *Adhatoda vasica*, *Tinospora cordifoloa*, *Sida* species for preparation of health care products for own health care and income generation; demonstrating and popularizing the planting of Bio-fences of economic use for protection of crops and income generation (*Jatropha, Carissa carandas, Caesalpinia crista* and *Punica granatum*-sterile variety); production and application of bio-control agent *Trichoderma* in crop production systems.

Envisaged outcomes/outputs:

- Production of crude extracts of poly-phenols for industry/product development; production of seed gums for the industry; crude and semi-finished health products for own use and marketing; production of *Trichoderma* at rural level; economic production from bio-fences and safety of crops from stray animals.

(iv) Appropriate technologies for rural development (CSIO)

Research focus

Entrepreneurship development programs on : repair & maintanencae of equipment for societal purposes such as agri-appliances, simple diagnostic instruments and common rural gadgets; assembly of telescopes, microscopes & associated gadgets for teaching; models and teaching-aids for science education in schools; dies and moulds for rural applications; bamboo splitting and Silvering machines and similar gadgets; low-cost tool rooms for rural areas

Envisaged outcomes/outputs:

- Models and teaching aids; dies and moulds; cost effective tools rooms

(v) Strategic Rural Income Enhancements by MIPs (Medicinal and Industrial Plants) based technologies (CIMAP)

Research focus

To develop Good Agricultural Practices (GAP) and Good Organic Practices(GOP) for specialty crops; selection of region specific superior genotypes and demonstration both under conventional and organic farming system: to demonstrate the economic utilization of waste/degraded lands through cultivation of some MIPs; demonstration of technologies related to managing farm waste and management of important pests and diseases through the use of bioinoculants; training the resource persons of nodal extension agencies (KVKs, SHGs, Extension centres etc.); to establish nodes for elite planting material of specialty crops for income Generation; development of products for rural cottage industries especially for empowering rural women; development of replicable models on e-farm advisory service for on-farm trouble shooting involving rural youth; setting up of information windows and testing centres (including mobile acility)for unreached at minimal costs; publication of GAP and GOP manuals Best Practice manuals for compost and planting material production and development of products for cottage industry, popular magazines and other modes of mass communication

Envisaged outcomes/outputs:

- **I**mprovement in the net returns of the farmers by cultivation of Medicinal and Industrial Plants from a unit area and to provide a quality raw material for industrial use; production of high quality produce on sustainable basis for the use in indigenous industry and for quality products; export potential of these plants and raw materials.

(vi) Organizing popularization programmes for quality production of aromatic plants in Uttaranchal (CIMAP)

Research focus

To popularize patchouli, vetiver, valerian, geranium and chamomile in different districts of Uttaranchal; to facilitate marketing linkages between produces/ growers and industry.

Envisaged outcomes/outputs:

- Generation of employment opportunities and better utilization of land and other available recourses optimally.

(vii) Demonstration and popularization of MAPs cultivation technology (ies) for entrepreneurship development in Gujarat state (CIMAP)

Research focus

To provide training to farmers for cultivation and production of priority MAPs suited to Gujarat region to develop entrepreneurship; to establish multiplication and chemical analysis facility for elite selected MAPs for the region.

Envisaged outcomes/outputs:

- Socio-economic upliftment of rural masses, employment generation, biodiversity conservation, quality raw material production, etc. in different phases is the region not covered so activily by CSIR/ CIMAP because of no centres in the region for MAPs.

3.2.15.10 CSIR for NORTH EAST

The North East is of immense geopolitical, geo-strategic and geo-economic importance bordering is Bangladesh, Bhutan, China, Myanmar and Nepal. The population is made up of numerous ethnic and tribal groups embracing almost all the major faiths of the world. The region accounts for 7.8 % of the total land space of the country. About 70% of the region is hilly, and the topography varies within each state. Mountains and hills cover most of Arunachal Pradesh, Mizoram, Nagaland, Meghalaya, Sikkim and about half of Tripura, one-fifth of Assam and nine-tenth of Manipur. The region is bestowed with rice as major crop, tea as major plantation and coal, petroleum and natural gas as major mineral resources. The region is the storehouse of horticultural products/ plantation crops/ vegetables/spices and valuable forest products and abundant forest resources. The region has a very rich biodiversity. There are 18 recognized biodiversity hotspots in the world, of which two are from Indian region (western ghats, eastern Himalayas- north east covers major part). Further, out of 17500 flowering plant species occur in India, 8500 are from this region and 1800 of them are unique not found anywhere in the world. The region also houses 825 out of 1150 species of orchid whereas out of 136 species of bamboos found in India, 63 species in 22 genera are found in Northeast India

The industrial sector has mainly grown around tea and timber in Assam and mining, saw mills and plywood factories in other parts of the region. The economy of the region is still primarily agrarian but its full potential is yet to be exploited. Since agriculture and industry have not really taken off inspite of the potential in the form of vast unexploited resource base available in the region. Sericulture in the North Eastern Region (NER) comprises the culture of four varieties of silk worms viz. Eri, Muga, Oak Tassar and Mulberry. While the third one is a new introduction and other cultures are traditional from time immemorial.

Northeast India also has a high diversity of non-flowering plants. Of about 1000 species of ferns found in India, nearly half are represented in Northeastern India. *Dipteris wallichii, Asplenium nidus, Osmunda cinnamomea, O. claytoniana, O.regalis, Helminthostachys zeylanica, Botrychium lanuginosum, Angiopteris evecta, Cyathea gigantea, C. spinulosa, Psilotum nudum, Phagopteres auriculata etc*, are some of the rare and interesting non-flowering vascular plants. Of these, *Platycerium wallichii* (Staghorn Fern) from Manipur appears to be the first report of its occurrence within India. This epiphytic fern grows in the moist deciduous forests in the Indo-Myanmar border areas in great profusion. Fern-allies such as *Lycopodium* and *Selaginella* are also diverse in this region.

The region is exceedingly rich in lichens, mosses and liverworts. These seemingly unimportant plants need to be investigated, studied, appreciated and above all, protected, as they serve vital ecological roles as soil protectors; contribute to the recycling of nutrients and water, offer food and shelter to an assemblage of invertebrates and take a part in air purification and carbon sequestration.

Activities of significant importance carried out earlier by CSIR are related to development of new drugs/diagnostics for Material by CDRI; domestication, mediculture, bioprospection, chemical processing and formulation and development of medicinal and aromatic plants. survey of Taxus wallichiana growing areas in Arunachal Pradesh by CIMAP; leather goods training facility at Guwahati, training-cum-production Centre for footwear and leather garments, Imphal, training-cum-common facility centre for cobblers, Dinapur, Nagaland, fallen carcass utilization Centre, Tripura and upgradation of Artisanal tanning units, Ukhrul, Manipur by CLRI; processing of and report on Pork processing at Bongaigaon, detailed project report on Bamboo shoot, ginger, chilli processing and cold storage plant at Kohima, pre-investment report on mushroom cultivation and ginger deydration in North-East & Sikkim, implementation of fruit processing plant at Mizoram by CFTRI, Mysore; seismic monitoring, seismic hazard Map of India including North-East Seismic studies at Tezpur, oil related investigations in Brahmputra Valley, determination of velocity structure of the North-East region by NGRI-Hyderabad; fresh flavour ginger oleoresin by RRL-Trivandrum; seismic risk analysis of RC structures by SERC; establishing an advanced technical training centre at Sikkim to impart technical skills in manufacturing technology, mechatronics and industrial automation and die mould making by CSIO.

CSIR focus for technology development during Eleventh Five Year Plan would be on

- Technology for economic growth - assist in deriving enhanced value from natural resources of the region
- Technology for human development - provide S&T based solutions to improve the quality of life of people of the region
- Science for Technology - encourage, direct & nurture highest quality science for the region.

More close and coordinated programmes between various CSIR laboratories and wherever possible with the R&D and academic institutes in the region would be attempted.

CSIR has its Regional Research Laboratory, RRL-Jorhat, situated in North East region which serves as window of CSIR to the North East. CSIR strives to contribute significantly in the development of the region addressing the sectors where CSIR has expertise. This would be further strengthened. The problems requiring S&T interventions of each state would be analysed and attempt would be made to create outreach units of RRL-Jorhat in each of the states to serve as the interface between RRL-Jorhat and other CSIR laboratories. These centres will be adequately equipped. Some of the programmes identified for the Eleventh Five Year Plan are:

Agro Food Processing

- Preparation of ginger products including paste, oil, oleoresin (CFTRI).
- Passion fruit products (CFTRI).
- pineapple, orange, jackfruit products – Osmo dehydration, IMF, beverages, jams (CFTRI).
- Turmeric processing (CFTRI).
- Chilli sauce (CFTRI)
- Potato processing plant.
- Revival of existing fruit processing plant (CFTRI).
- Demonstration Unit Rice milling-cum-oil extraction (RRL-Jorhat).
- Maize milling plant – revival.
- Demonstration Unit Dal mill (CFTRI).
- Oil expeller (MERADO-L).
- Cinnamon oil & products (RRL-Bhub.).
- Demonstration unit on cardamom drying (CFTRI, RRL-Bhub.)
- Spice processing plant (RRL-Triv.).
- Egg preservation & coating oil (CFTRI).
- Pork processing for ham & bacon (CFTRI).
- Modern slaughter house (CFTRI).
- Leaf cups & plates.
- Arecanut leaf cups & plates.
- Mushroom cultivation (RRL-Jorhat).
- Quail farming (RRL-Jammu).
- Power paddy thresher-cum-winnower (RRL-Bhub.).

Cultivation & Processing of medicinal, aromatic & remunerative crops

- Cultivation & distillation of citronella & lemon grass in Jhum lands (RRL-Jorhat).
- Bamboo nursery (IHBT).
- Bamboo tissue culture laboratory (NCL).
- Low cost green house (IHBT).
- Taxus wallichiana – clonal propagation (RRL-Jammu).
- Floriculture, packaging of cut flowers bulbs, tubers for export (NBRI/IHBT).
- Floral crafts (NBRI).
- Tea leaf plucking machine (IHBT/CMERI).
- Fast growing sps (RRL-Jorhat).

Water & sanitation

- Setting up water treatment plant for fluoride and iron removal (NEERI).
- Water defluoridation plant (CECRI).
- Ground water prospecting (NGRI).
- Rain water harvesting (CBRI).
- Pedal pump (CMERI).
- Samira wind pump for water lifting (NAL).
- Solid waste management at Shillong (NEERI).
- Wetland management in Loktak lake (RRL-Bhopal).

Construction technologies

- Low cost housing and construction materials (CBRI).
- Shelter planning, new materials, processes, structure, foundation and disaster management (CBRI).
- Accoustical design of Saikufi hall at Lungnei, PWD (CBRI).
- Production of stabilized mud blocks (CBRI).
- Production of solid stone blocks & concrete blocks (CBRI).
- Semi-automatic brick making and high draught kiln (CBRI).
- Design for ventilation and lighting in rural houses (CBRI).
- Banana fabric based composite doors (RRL-Triv.).
- Water proofing of buildings (CBRI).
- Improved techniques for strengthening repair of concrete structures (SERC).
- Knowledge-based seismic design of reinforced concrete buildings (SERC).
- Mini cement plant – rejuvenation (RRL-Jorhat).
- Material design and quality control for flexible pavements including road drainage in high rainfall hilly areas (CRRI).

Leather & footwear

- Leather goods manufacturing training facility (CLRI).
- Upgradation of artisanal tanning unit (CLRI).
- Improved tools for leather artisans (CLRI).

Artisanal skill development/ other cottage industries

- Lead-acid battery manufacture & maintenance, (Rs. 1.5 lakh for a T&D) (CECRI).
- Sericulture including high yielding silkworm strains for Tassar (IICT).
- Rural blacksmithy & farm implements making (NML).
- Installation of solar street lights with auto-switching (Rs. 31.000 each) (CECRI).
- Briquet (CFRI).
- Dust chalk (RRL-Jorhat).
- Biomass drier-cum-bukhari (RRL-Bhub.).
- Repair and maintenance of scientific instruments (CSIO).
- Multi-fuel chulha (RRL-Bhub.).
- Pottery units modernization (CGCRI).
- Water filter candle making (CGCRI).
- Reclamation of Mined-Out Areas in the N-E State of Meghalaya)

Dissemination of knowledge base

- Training and demonstration activities regarding preparation of ginger products
- Training-cum-Production Centre for wool-knit footwear & leather garments (CLRI).
- Training in water quality assessment (NEERI/ITRC).

3.2.15.11 FACILITY CREATION

(i) State of Art analytical facility for north east region (RRL, Jorhat)

It is a state of art analytical facility for testing the bioactive principles present in herbal and plant resources of the region and for food product analysis. The facility would help in developing food, functional and health food supplements for the benefit of the people

Aim of the facility

- To build the state of art analytical facility for testing the bioactive principles present in herbal and plant resources and for food product analysis.
- Screening of herbal and plant resources of north east by testing the herbal or plant material for nutraceutical bio-principles which are responsible for enhancement of defence mechanisms, prevention of specific diseases, recovery from diseases, control of physical and mental conditions.
- Testing the herbs and plant materials for dietary fiber, oligosaccharides, sugar alcohols, amino acids, peptides, proteins, glycosides, alcohols, isoprenoids, vitamins, cholines, lactic acid bacteria, minerals, poly unsaturated fatty acids, chlorogenic acid and poly phenols (anti-oxidants) which are identified as nutraceutical compounds.
- Relating the ingredient component for the health promoting properties such as calcium for osteoporosis, sodium for hypertension, dietary fiber and cancer, folate and cancer, folate and neural tube defects, protein and coronary heart disease, phytosterols and CHD, omega 3 fatty acids and CHD etc., in case a new component with nutraceutical properties are isolated a detailed study will be carried out.

Envisaged outcomes/outputs

- Bioassay facility on extraction and commercialization of bioactive substances from plant sources. The facility would help in developing food supplements functional and health food supplements for the benefit of the people.

Total Plan budgetary requirement projected for the Sector is Rs. 382 crore

3.2.16 WATER :RESOURCES & TECHNOLOGY

India is one of the wettest countries receiving as much as 4000 billion cubic meters of rainfall every year. Barely a third of the potentially available water is being utilized. With rapid population growth and rising expectation for a better life, this natural resource on earth faces an increasing pressure. In context of India, while an average person was having annual access to 5177 Cum of fresh water in 1954, it has fallen to 1869 Cum in 2005. It is projected that by 2025 the availability will be below 1000 Cum which will represent acute scarcity levels. The rapid industrialization and indiscriminate use of chemicals in agriculture are polluting the known resources of fresh water thus further aggravating the problem.

Over the years the issue of safe drinking water has gained national importance. The challenges that are posed for achieving this goal are to provide technologies that are affordable, accessible and acceptable. Issues that primarily concern safe drinking water are presence of pathogenic micro-organism, hazardous heavy metals, inorganic salts and pesticides. The areas in which technological interventions are required include water purification, recycle/reuse, brackish water treatment and desalination of brine water. Many CSIR labs have initiated programmes for providing technological interventions in making safe drinking water availability to masses.

The eleventh plan of CSIR in the area of 'water' aims at delivering products and systems which will further strengthen our efforts in developing affordable, accessible and acceptable technologies for fulfilling the national requirements in public and social sectors. The proposals put forward broadly cover important areas, viz., cost effective mine water reclamation technology for providing safe drinking water, sustainable development of ground water resources in problematic terrain, use of membrane bioreactors for recycling of water from industrial waste water, hollow fiber membrane technology for water disinfection/purification and waste water reclamation, membrane technology for water purification and desalination and technology package for high capacity arsenic removal plants and wastewater treatment using ceramic MF-UF membranes. All these 8 proposals are covered under network scheme of implementation.

NETWORK PROJECTS

3.2.16.1 Development of cost effective mine water reclamation technology for providing safe drinking water (*CMRI*, Dhanbad)

In spite of the availability of large water resource in the form of mine water in the area around Dhanbad, Jharia and other mining belt of India, the mining areas suffer from acute shortage of potable water. In view of this, a project is proposed for development of cost-effective technology for harnessing mine water resources of the area for drinking water purposes.

Research focus

- To develop audit protocol for assessing the water discharge.
- To develop comprehensive database for coal mine water quality of the region.
- To develop low cost treatment technologies for the purification of coalmine water with safe sludge disposal.
- Translation of the developed technology to pilot scale.
- To design and develop appropriate distribution system

Envisaged outputs/outcomes

- Development of water quantity and quality assessment protocols.
- Development of technology package for purifying mine waters for the purpose of drinking and making it available to the people.
- Development of technology package for safe sludge disposal.
- Setting of pilot plant based on developed technology for about 2000 people.
- Technology transfer to other coal mines.

3.2.16.2 Sustainable development and management of water resources in different problematic terrain (*NGRI*, Hyderabad)

Water resources of many regions in the country face problems owing to fractured, alluvium or Island terrain. The proposal is to augment techniques to exploit water resources in these areas. It involves development of technique to delineate, characterize and assess groundwater potential through geophysical, hydrogeological, geochemical, isotope and mathematical modeling techniques.

Research focus

Activity I:

- Delineation of potential groundwater source through geophysical and hydrogeological investigations
- Integration of geo-information through GIS to delineate potential zones for groundwater,
- Geophysical & Hydrogeological investigations to delineate aquifer system and various stresses on it,
- Simulation of aquifer system and assessment of groundwater potential, and
- Development of scheme for sustainable water supply.

Activity II :

- Augmentation of water resources through Artificial Recharge & Rainwater harvesting :

FIRST STAGE [First Year]

- Selection of model tank and delineation of catchment and defining as watershed in two major soil type areas (Alfisol & Vertisol)
- Studying tank function under present condition
- Studying the groundwater condition in command area

SECOND STAGE [Second Year]

- Designing for modification of irrigation tank to improve its functional potential and executing with the help of irrigation departments in Alfisol area
- Designing modification to improve the percolation tank efficiency and for increasing the influence area for the same harvesting potential of the tank in Alfisol area

THIRD STAGE [Third Year]

- Designing modification to improve the percolation tank efficiency and for increasing the influence area for the same harvesting potential of the tank in Vertisol area

FOURTH STGAGE [Fourth Year]

- Continuing the impact assessment of modified irrigation system for subsequent hydrological year in Alfisol & Vertisol areas

FIFTH STAGE [Fifth Year]

- Enlarging the strategies adopted to improve the functions of harvesting structures through data analysis to the concerned departments
- **Activity III**: Water and solute movement studies for sustainable agriculture
- Water and solute movement through unsaturated (vadoze) zone in fertilizer applied irrigated fields. The dynamic process, quantification and factors affecting its retardation and movement will be studied through hydro geological, hydro chemical and tracer techniques.

- Delineating flow pathways in saturated and unsaturated zone during the time of deep percolation or groundwater recharge in unsecured land fill areas.
- Evaluation of return flow due to canal water applied irrigation in overexploited alluvial areas of north India through soil moisture studies by neutron probe and radiotracer techniques.

Activity IV:

- Sustainable fresh water in Anthropogenically Polluted area /toxic metals, pesticides, other industry-specific chemicals

Activity V:

- Rock-water interaction in naturally groundwater polluted area
- Ecotoxicological studies of Contaminated site,
- Radioactive element pollution studies,
- Natural Contamination : (e.g. fluorine, arsenic, chromium) in soil and sediments

Activity VI :

- Potable Groundwater Resources on Island/coastal region
- Geophysical & Hydrogeological investigations to delineate aquifer system and various stresses on it,
- Simulation of aquifer system and assessment of groundwater potential, and
- Development of scheme for sustainable water supply.

Activity VII:

- Groundwater management in mining environ
- Envisaged outputs/outcomes
- Development of technique to
- assess groundwater potential zone on Island,
- characterize aquifer system in alluvium and fractured terrain,
- Simulate aquifer system in different geological terrain.
- Consolidated data base on groundwater quality, contamination, and its mapping for developing future strategies for management of groundwater resources in the region known for high industrial and agricultural activities
- Assessment, identification and apportionment of contaminants sources through the application of advanced methods, such as multivariate, multi-way, and geo-statistical modeling tools.

3.2.16.3 Development of hollow fiber membrane technology for water disinfection/purification and waste water reclamation (CSMCRI)

Hollow fibre membranes are flexible, have large surface area, low operation cost and produce no waste product are increasingly used for water treatment. Proposal is for development of indigenous technology for preparation/ spinning of polymeric hollow fiber membranes useful for removal of pathogens and for waste water treatment.

Research focus

- Preparation/spinning of hollow fibers from indigenously available polymers such as polysulphone (PS), polyethersulphone (PES) and polyacrylonitrile (PAN)

- Preparation/spinning of hollow fiber (HF) membranes with molecular weight cut-off (MWCO) in the range of 50-60 K for ultrafiltration applications.
- Evaluation of PS, PES and PAN hollow fiber membranes (test cartridges) in the laboratory for the removal of pathogens, bacteria, virus, colloidal material & turbidity from water.
- Identification/selection of the most suitable and appropriate polymer for hollow fiber membrane development.
- Development of novel point-of-use water purification modules based on hollow fiber membranes.
- Modification of the existing hollow fiber spinning device/machine

Envisaged outputs/outcomes

- Fabrication of point of use and pilot scale Hollow fiber based water purification units.
- Domestic hollow fiber cartridges/units for water purification and disinfection.
- Hollow fiber based membrane bio-reactors for treatment of domestic sewage water
- Fabrication and installation of submersible hollow fiber systems for water purification
- Fabrication and installation of submersible hollow fiber systems for effluent treatment and secondary treatment of sewage water.
- Indigenisation of hollow fiber membrane technology for UF applications

3.2.16.4 Membrane technology for water purification and desalination(CSMCRI,: NCL, Pune; CGCRI, Kolkata, DST, New Delhi; BARC, Mumbai; DRL, Jodhpur; CPCL, Chennai, Ion Exchange (India) Ltd., Mumbai; Gujarat State Fertilisers Corporation, Vadodara; Rajasthan State Mines & Minerals Ltd., Nagaur (Rajasthan)

The project proposes to develop high salt-rejection RO membranes for seawater desalination, nanofiltration membrane technology for water purification/decontamination (removal of Fluoride, Arsenic, Nitrate and Hardness ions) and UF membrane technology for water disinfection. The projects also aims to develop competency in spiral winding for rolling of different size spiral membrane modules from flat sheet membranes for UF/NF/RO applications.

Research focus

- Achieve 99% rejection of total dissolved salts with the indigenous thin film composite (TFC) RO membrane for single stage seawater desalination so as to produce (a) water for drinking, (b) water for agriculture, (c) water for industrial applications.
- Preparation and application of Nanofiltration membranes for (a) water purification/decontamination by way of removal of fluoride, nitrate and arsenic from drinking water (b) brackish water softening/hardness removal (c) seawater softening/brine purification
- Upgradation and automisation of membrane casting and coating machines for scale-up activities
- Creation of state-of art spiral module rolling facility
- Upgradation and automation of RO plants
- Utilisation of RO reject water for wasteland development
- Nanofiltration studies for treatment of RO reject water

Envisaged outputs/outcomes

- Fabrication and installation of seawater RO plants (based on improved membrane) in the coastal areas.
- Wind mill-powered RO plants for seawater desalination in the coastal areas
- NF membranes with specific selectivity to fluoride, nitrate and arsenic.
- Application of NF membranes for water softening (hardness removal) and as a pretreatment to seawater RO
- Operation of brackish water RO plants with very high recoveries (85-90%) followed by nanofiltration of reject water (NF as a post-treatment).
- Water disinfection using UF membrane based spiral modules
- Application of UF membranes as a pretreatment to RO desalination.
- Implementation of reject water utilisation/treatment methods for all our existing brackish water RO plants
- Indigenisation of brackish water membrane technology

3.2.16.5 Development of technology package for high capacity arsenic removal plants and wastewater treatment using ceramic MF-UF membranes(CGCRI, NEERI, NML ITRC, IICT & RRL-Jorhat)

The proposal envisages to develop of low cost units for safe drinking water supply in rural areas and environmental protection through sludge management and wastewater treatment with reuse/recycling. High Capacity arsenic removal plants using colloidal adsorbent media and more efficient ceramic elements along with cross flow micro-filtration/electro-oxidation-coagulation treatment /fixed bed catalytic reactor/membrane contactor will be employed as attachment to deep tube wells.

Research focus

- Development of Technology Package for High Capacity arsenic removal plants for attachment to deep tube wells using:
  - colloidal adsorbent media and more efficient ceramic elements along with cross flow micro-filtration/electro-oxidation-coagulation treatment /fixed bed catalytic reactor/membrane contactor,
  - In-situ treatment of groundwater and scale up of the technology
- Utilization of knowledge generated for system development on
  - Potabilisation of surface and sub-sub-surface water
  - Colour removal from textile wastewater and supply of technology package for evaluation at NEERI
  - Evaluation of newer adsorbent materials and systems for removal of arsenic, fluoride, hydrocarbon oil, heavy metals, etc

Envisaged outputs/outcomes

- In-situ Treatment Techniques for Arsenic Removal
- Process for manufacturing porous ceramic elements
- Process for stabilization and solidification of arsenic wastes.
- Process for arsenic recovery from the sludge
- Rapid Detection Kits for water quality monitoring

- Technology package for colour removal from textile dye bath waste water Technology for treatment of oily wastewater from vegetable oil industries
- Technology package for reclaimation of wastewater generated from oil fields
- Development of low cost units for safe drinking water supply in rural areas
- and environmental protection through sludge management and wastewater treatment with reuse/recycling

2.3.16.6 Onsite technological intervention for remediation of water resources pollution (NEERI, RRL-Bhubaneswar, ITRC, RRL-Bhopal)

The water resources in the country are under continued threat of chemical and bacteriological contamination. Heavy contamination of surface water bodies during last few decades has led to the shifting of enormous pressure on the groundwater resources, considered to be relatively safe. Over-exploitation of these resources, reduced capacity recharging and increasing industrial and agricultural activities have adversely affected the groundwater quality. The proposal aims at generating data and models for prediction and remediation of ground water contamination through arsenic, fluorides and other chemicals.

Research focus:

- Sustainable water resources management in the hilly region with particular reference to technological intervention for organised safe drinking water supply
- Development of a model for assessment of Stratographic influence on mobility of arsenic and onsite control of arsenic in public water resources
- Study of the mechanism of fluoride leaching into ground water through detailed hydrogeological investigations
- Development of site-specific control technologies and strategies for mitigating the toxic effects of the organic pollutants (thms, pesticides, organometallics and pahs)
- Development of low cost & advanced ‘terafil’ assisted domestic and community water filtration & treatment devices suitable for habitats of north eastern states and hilly areas
- To improve scientific understanding on water- minerals strata interactions vis. a vis. phenomena of clogging of water galleries.

Envisaged outputs/outcomes

- Technology package for sustainable management of water resources in hilly regions
- Design, development and demonstration of arsenic removal technology for societal benefits through provision of arsenic-safe water to the communities
- Onsite pollution abatement strategies

3.2.16.7 Treatment methodologies for water& wastewater (NEERI,CECRI, IGIB, RRL – Jorhat, CFRI, RRL, Bhuvneshwar)

Several industries in India are under tremendous pressure to adopt methods to recycle/reuse water either due to unfit nature of effluents for discharge through any approved disposal methods or facing acute shortage of process grade water. The quality requirements of process grade water differs from industry to industry and many a times the total dissolved solids (TDS) are required to be brought down substantially before being recycled. Advanced oxidation processes are considered one of the most attractive methods for the treatment of water and wastewater containing toxic and non-biodegradable pollutants. NEERI has created a sound knowledge base and expertise which will be utilized for reclaimation and reuse of effluents from textile industry, sanitary disposals, etc.

Research focus

Development of advanced oxidation processes for treatment of water and wastewater containing toxic and non-biodegradable pollutants. Advanced oxidation processes (AOPs) use combinations of oxidants, ultraviolet irradiation and catalysts to generate hydroxyl radicals (OH•) in solutions and have attracted interest for the degradation of biorefractory or hazardous organic compounds in wastewater. The organic pollutants are oxidized by free radicals and mineralized to water, carbon dioxide and mineral salts. A number of studies have indicated the potential for using AOPs to destroy micro-pollutants completely such as pesticides.

Envisaged outputs/outcomes

- System for water resources management operating at different geographical and temporal scales for planners and policy makers.
- Process package for treatment of industrial wastewater using EAW system with special reference to metallurgical and mineral industry.
- Development of scientific understanding of phyto- & bio-remediation process and identification of pollutant specific species

INTERAGENCY PROGRAMMES

3.2.16.8 Utilisation of indigenous know how to address drinking water need in coastal/ rural areas (*BARC- Mumbai*, CSMCRI,NCL,CGCRI)

The Scientific Advisory Committee to the Prime Minister has desired BARC and CSIR to jointly put up a project on drinking water for rural areas specifically for problem areas in interior and coastal and areas facing problems of bacterial contamination and salinity, and also water contamination by arsenic and fluoride. BARC is submitting an interagency proposal of Rs 500 crores networking the competencies of various public R&D institutions and involvement of private stake holders to achieve the desired objectives.

As part of interagency programme of BARC, CSIR is submitting a proposal of Rs 60 crores. The CSIR project envisages upgrading of membranes and resins facilities at its laboratories namely CSMCRI, NCL and CGCRI with adequate scale up facility to meet the requirements under the proposed inter-agency project and other projects as well. The proposed programme would provide all types of membrane and resin manufacturing facilities including design, hardware and plants based on our knowledge and experience acquired after working for a long period. The facilities would not only cater to large scale requirements but enable CSIR to showcase its technologies with the intent of licensing.

CSIR will feed its technologies and products into the BARC-CSIR inter-agency programme with public-private partnership.Membranes and resins facility at CSMCRI

Research focus

- State of art TFC RO membrane making facility with large scale production
- (1000 m^2 per day)
- Module making facility for 2” to 8” dia. RO modules

- Complete RO plant fabrication and testing facility
- Hollow fiber spinning and module making facility
- Advanced research facility for new membranes
- Backward integration of manufacturing for materials and chemicals
- Large scale manufacturing of resins and design of plants for removal of fluoride, arsenic and nitrates
- Disinfectants and clarification technology
- Advanced ED membrane facility
- Ceramic membrane making, modules and systems at CGCRI
- Ultra-filtration membranes and systems at NCL

Envisaged outputs/outcomes

- Production of various types of membranes for micro, ultra and nano-filtration and RO and resins on commercial scale
- Capability of making large number of modules of different sizes
- Manufacturing of household to very large capacity plants for water disinfection, clarification, treatment of brackish water / sea water, waste water reuse and removal of harmful impurities without / with hardness.
- Catering for clean water requirements for public and industrial applications of membranes
- Advances in membrane science and technology
- Quality control and instrumentation laboratory
- Regeneration facility for minimum discharge of effluents

Total Plan budgetary requirement projected for the Sector is Rs. 210 crore

3.2.(b) ONGOING COMMITMENTS

During the Tenth Five Year Plan CSIR under the National Laboratories scheme initiated 56 network projects under S&T Mission Mode, CSIR Mission Mode and CSIR Core Projects. CSIR would be completing most of the ongoing programmes, however some of the projects which could only be initiated during the middle of the plan, due to delay in obtaining approvals etc., will spill-over to the Eleventh Five Year Plan. CSIR has re-assessed the relevance and positioning of these on-going programmes and will be persuing only those of the projects which would realize the desired high value outcomes. Accordingly, following Tenth Five Year Plan projects will spill-over to Eleventh Five Year Plan:

1. **Spearheading small civilian aircraft design, development & manufacture;**
2. **Newer scientific herbal preparations for global positioning;**
3. **Acquisition of oceanographic research vessel (ORV) for oceanographic research;**
4. **Setting-up a world class drug research institute;**
5. **Drug target development using in-silico biology;**
6. **Upgradation of SI base units, national standards of measurements & creation of a network of calibration and testing laboratories and preparation & dissemination of CRMs ;**

7. **Developing and sustaining high science & technology for national aerospace programmes;**
8. **New and improved road technologies;**
9. **Establishing national science digital library (NSDL);**
10. **Development of comprehensive technology for disaster prevention and management of Jharia coalfield;**
11. **Discovery, development and commercialization of new bioactives and traditional preparations;**
12. **Setting up of national facility for advanced proteomics research;**
13. **Genetically modified food referral facility.**

Total Plan budgetary requirement projected is Rs. 600 crore

3.2. (c) CREATING NURTURING AND SUSTAINING THE CORE KNOWLEDGE FRONTIER

Research as an activity comprises two main components viz, acquiring understanding (basic science) and acquiring capability (basic technology). Basic research is the major source of advancement of knowledge in science and lays foundation for development of newer cutting edge or generic technologies of the future. Basic technology is often multi-disciplinary and is a crucial element in the research & innovation process. Through the core competence build up programme, the support to laboratories will be provided for the deployment of generic technology base that can be adopted to a diverse range of scientific research problems and challenges.

The core competencies need to be continuously developed in the areas of aerospace science, modern biology and biotechnology, chemistry, geophysics, oceanography, material science, etc. This is strategic for the newer developments in the frontier ,inter-disciplinary AND cutting edge areas, for example, aero-acoustics & aero space materials, nano-biotechnology, post-genomic medicines, cell & tissue engineering, fuel cells, green chemistry, polymer materials, nano-materials, fibre reinforced plastics and nano composites, new interpretation techniques in mineral exploration & engineering geophysics, etc. Through its respective Research Councils CSIR laboratories, would identify and implement specific R&D projects in frontier and trans-disciplinary areas which require a sound base in basic research. Selective support would be provided for such projects for further development of core competencies. The support in terms of equipment and creation of related new facilities as well as support for chemicals consumables, contingencies would be provided under the development of core competencies.

Total Plan budgetary requirement projected is Rs. 1000 crore

3.2. (d) SCALE-UP AND VALIDATION OF LEADS DEVELOPED IN-HOUSE

CSIR at its various constituent laboratories has developed promising leads that require scale up/validation. This is more true for the areas of Drugs & Pharmaceuticals, Chemicals and Biotechnology where several leads/targets have been identified / developed under various projects under Tenth Plan. In addition, a few more are expected to be generated during the Eleventh Plan period and they may even extend to the areas of Electronics, Materials and Minerals. However, many of these cannot reach industry since they have not been scaled up/validated, at scales acceptable to industry for undertaking appropriate techno-commercial level. Pharmaceutical industry on its part, has strengths in product development, large scale production and marketing and depends on R&D institutions mainly for: a) specialized knowledge base and skill-sets to supplement their R&D – Pathway analyses, protein engineering, drug designing, molecular modeling, designing novel experimentation, computational analyses, etc., b) generation and screening of libraries of potential compounds c) contract manufacturing and d) preclinical studies with an ultimate objective to have validated/screened targets that could be taken on commercial scale for economic benefit. Target-validation technologies are, thus, in strong demand and are the most critical challenge facing large pharmaceutical companies world over. Target validation involves proving that the molecule (say DNA, RNA or a protein) is directly involved in a disease process and can be a suitable target for development of a new therapeutic drug.

In the areas of Electronics, Minerals and Materials the scale-up studies will extend to developing prototypes for assembly line production capabilities, which could be translated into actual production models easily and sustainably.

In so far as the areas of drugs & pharmaceuticals is concerned, CSIR under the Tenth Plan has developed a number of potential leads/drug targets in the areas of cardiovascular, infectious diseases, respiratory and compex metabolic disorders that have diagnostic/therapeutic intervention potential. In addition, CSIR has also initiated programmes in discovery and development of Bioactives and Traditional (scientific herbal) preparations, Bioinformatics for Health and Drug development. The leads from these projects need further screening, scale up/validation before they could be taken by industry. CSIR recognizes that the new paradigm of drug discovery calls for a significant increase in the number of new candidates in the pipeline. Screening and scale up expertise play a crucial role here. It not only enables considerable reduction in the unit production cost, but could provide large pharmaceutical companies adequate quantities of products for their independent testing/validation. Validation and scale up expertise together are key to significant reduction in the unit cost of discovery by reducing failure rates. World over, leading R&D centres have recognized it and have set up strong scale up/validation systems either in-house or have outsourced the activity. What is true for the areas of drugs and pharmaceuticals is equally applicable for other sectors of science and technology.

In view of above it is proposed that CSIR initiates focused activity in the areas of validation and scale up. First, this would enable CSIR to take the leads/targets it has developed to the next stage and develop a strong pipeline of potential compounds/libraries. Second, with this set up it could effectively partner with industry to address some of their issues that need advanced R&D interventions. This would provide platform for linking CSIR's knowledgebase to economic and social benefits. Third, it would provide on the job training to create a pool of trained scientists/lab resources. These activities by themselves would lead to innovation and help position CSIR in global R&D space.

This scheme would be operated through the setting up of five stand-alone centres located in five laboratories from the appropriate S&T areas. These centres would be provided with facilities germane to scale-up from nano to multi, gram to kilogram and beyond scales or from a few units to assembly line prototypes.

The total budget estimate for supporting validation and scale up centres is around Rs. 500 crores.

Total Plan budgetary requirement projected is Rs. 500 crore

3.2. (e) OPEN SOURCE DRUG DISCOVERY PROGRAMME FOR INFECTIOUS DISEASE

The cost of development of a new drug is approximately between US $ 300-500 Million. The discovery and development of drugs by pharmaceutical companies are driven by market size and price. Such companies do not wish to invest huge money in discovering drugs for such disease conditions which do not give them the commensurate market size and price. Diseases of the third world, particularly the infectious diseases, therefore do not fall under their immediate research priority. They know it too well that half the populations of the world including 50% of Indians do not have the paying capacity although they need it the most. In addition, two other issues are responsible for poor development of drug leads in area of infectious disease. The prohibitive cost of IPR protection and maintenance, and confidentiality of drug development which does not allow collective efforts of the best brains of the world available in National Laboratories and Academic Institutions to work together with industries. However, the remarkable success of the open source movement in IT Sector like development of Linux operating system and World Wide Web has given enormous benefit to the developing world. This model, therefore, merits a serious consideration for extension and adoption in the area of new drug discovery.

CSIR being responsible for the development of affordable healthcare for the people of India, plan to initiate and lead open source drug discovery programme. Presently, such efforts of bringing academic and other not-for-profit entities to drug discovery for neglected diseases are being undertaken by agencies like Global Tb Initiative, Welcome Trust, Gates Foundation, Tropical Disease Initiative (TDI) etc. In the Eleventh Plan it is proposed that CSIR should set up programmes for open source drug discovery through national and international collaborations involving National Laboratories and Academia. “Open Source Drug Discovery Movement” is a new concept and has major advantage of reducing the cost of development by bringing like-minded scientists with complementary diverse skill set together under a single umbrella. Incentive scheme in this programme will not be royalty and intellectual fee for IPR developed, but recognizing contribution by awards and prizes. The remarkable success of open source movement in IT sector gives confidence to the potential success of such a movement in healthcare sector.

The scheme would be operated through funding development work on known leads available in public domain; acquiring leads and working further on them; and developing new leads. All such developmental work would then be passed on as a free-ware, open for further development by votaries of “open source” movement. These initiatives are likely to bring down the drug developmental costs substantially, thus benefiting developing economies like India.

Total Plan budgetary requirement projected is Rs. 500 crore

3.2. (f) LABORATORY MODERNIZATION FOR ECO FRIENDLY SUSTAINABLE GROWTH

Modern building infrastructure and related facilities take into consideration the eco-friendly and cost-effective maintenance technologies such as energy efficient air conditioning systems coupled with energy efficient lighting devices. They also have in-built mechanism of recycling of water used for various purposes and also water harvesting to maximize the cost reductions in inputs for the system. These are one time investment to the system but induces lot of savings in future. For CSIR which is a non profit organization there is an urgent need to cut down on operating expenses to sustain itself economically in the long run. In the Eleventh Plan CSIR proposes to adopt eco friendly building components, such as, energy efficient air conditioners, solar panels for lighting and other uses, rain water harvesting, recycling of waste water etc. This approach will not only help CSIR in minimizing the operating expenses but would also find solution to problems like shortage of water and electricity.

Total Plan budgetary requirement projected is Rs. 500 crore

3.2. (g) CIVIL INFRASTRUCTURE RENOVATION, STAFF QUARTERS AND AMENITIES

Many of the CSIR laboratories were built or acquired in fifties/sixties some even earlier. While some of the laboratories were started from the buildings meant for palaces, educational institutions and in rented places, some of them built R&D facilities of the contemporary period. Most of them are now more than five decades old and are not very appropriate for modern day R&D activities. Though on a selective basis, in the Tenth Plan renovation was carried out in CSIR laboratories but much more was needed and could not be pursued due to lack of funds. In the present day of globalization with many MNC's opening their R&D centres in India, it is a prerequisite for CSIR's R&D establishments to up-grade their basic infrastructure. The modern facilities would therefore go a long way in increasing the productivity of the employees by providing good working environment. CSIR would like to take up substantial renovation work including several new works for premises of its laboratories.

It is recognized that good housing is one of the prerequisites to attract talent to R&D generally and in the CSIR system more particularly. In the Tenth Plan, the scheme on residential building was merged with the national laboratories to provide focus and necessary support. CSIR laboratories are spread throughout the country and many of them are in remote places like, CEERI Pilani, IHBT Palampur, CECRI, Karaikudi, CMRI/CFRI, Dhanbad, CSMCRI, Bhavnagar etc. lack of housing is one of the major constraints to attract and retain talented scientists at CSIR laboratories not only at remote places but even at reasonably decent cities/towns. The satisfaction level for housing in CSIR is estimated to be of the order of 35% only, which needs to be enhanced to at least 60% in metro cities and 100% in remote places. Selective support is required for construction of dwelling units at various places depending on the need in the Eleventh Plan. Besides infrastructure and housing, other amenities such as dispensaries, health centres, community centres etc are also very much required for the welfare of the staff living in far off places from the city centre. Under the Eleventh Plan CSIR would support creation of new dwelling unit as well as these amenities on a selective basis.

Apart from the above, CSIR in the Eleventh Five Year Plan would also build convention centres at selected laboratories working in physical, chemical , biological and engineering sciences. The convention centres will provide world class facilities to help intermingling of bright minds to exchange their ideas. These centres will provide ambience for creative thinking and help scientists network and come up-with innovative research ideas. It is proposed to build 10 national centres across the country and 1 international convention centre at Delhi during the Eleventh Five Year Plan.

Total Plan budgetary requirement projected is Rs. 1000 crore

3.3 NATIONAL S&T HUMAN RESOURCE DEVELOPMENT

Human Resource Development is of paramount importance in the national building process and creating a knowledge society. CSIR has been rendering yeoman service by fostering, sustaining and helping the specialist scientists in diverse disciplines of S&T in the country. In the era of globalization, recognizing the changing context of the scientific enterprise and to present national needs, there is need to vigorously foster scientific research in universities and other academic, scientific and engineering institutions, and attract the brightest young persons to careers in science and Technology.

A serious concern was expressed over decreasing interest of young talented people to take up careers in basic sciences in the fifth meeting of the Scientific Advisory Committee to the Cabinet (SAC-C) held in March 2003. There is, thus, a need to progressively increase the rate of generation of high quality skilled human resource at all levels. This was also highlighted in Science and Technology Policy 2003. Furthermore, efforts would be made to convey to the young, the excitement in scientific and technological advances and to instill scientific temper in the population at large. This process would naturally entail reversing the present flow of talent away from science by initiating new and innovative schemes to attract and nurture young talent with an aptitude for research. Flexible mechanisms are required to be put in place in academic and research institutions to enable researchers to change fields and bring new inputs into traditional disciplines and also to develop inter disciplinary areas. Furthermore schemes for continuing education and training of university and college teachers in contemporary research techniques and in emerging areas of science are required to be strengthened.

Proposed Programmes

National Science Survey 2004, as reported in India Science Report, has identified that the annual intake of students studying science has recently risen , but the lower follow-through to higher levels, particularly doctorates could lead to shortage of technically qualified teachers. There is thus a desperate need to progressively increase the rate of generation of high quality skilled human resource in basic and engineering sciences. The number of candidates applying for National Eligibility Test (NET) for Junior Research Fellowship (JRF) to do PhD in basic sciences has tremendously multiplied over the years. From around 5500 candidates in the March 1983 examination, it has reached 79,500 for the December 2005 Examination. CSIR provides support in the form of JRFs to around 1200 fellows through NET each year to do PhD. This number is quite small keeping in view the number of students appearing in the exam, and has to be substantially increased to cater to the current need. In the Eleventh Plan the emphasis is being relied on JRF in Basic Science and accordingly a major plan scheme being initiated which essentially would focus on this important stream of science.

JRF- GATE Scheme has been introduced some time back as a pilot exercise to promote research in engineering and pharmaceutical sciences by contributing to lab research through a suitable PhD programme. The scheme is now being formalized. JRFs selected under this scheme will have an excellent opportunity to work with the CSIR scientists with state- of- art R&D facility and obtain PhD degree. CSIR-National Innovation Fellowship Scheme is also being formalized to strengthen and harness Indigenous knowledge for the purpose of wealth and employment generation. Science is becoming increasingly inter and multidisciplinary and calls for multi institutional and in several cases multi country participation. To facilitate collaborative supervision of PhD students in interdisciplinary areas, the scope of the JRF-NET & Trans-disciplinary Fellowship scheme will be further extended by providing special incentives to supervisors and students, exercising the option to work with more than one supervisor, across disciplines in CSIR Institutes.

Through the proposed new scheme called "Adjunct Scientist /Visiting Scientist Scheme", an effort will be made to tap the available expertise from institutions from India and abroad, on a temporary basis, to accelerate the development of new expertise and areas of research in CSIR Institutes. The scheme envisaged would provide a formal mechanism for not only exchanging scientific ideas but also to try out new ideas, particularly from the visiting faculty. Furthermore, in the knowledge based economy, research scientists and scholars are required to be empowered with additional skills of knowledge / innovation and R & D management through suitable training programmes & setting up of centres in these areas, if India is to compete globally. "Project Intern Award" scheme is being launched to provide a preparatory phase for young interns in imbibing the spirit of enquiry and learning the tools and techniques of research.

The quality and quantum of scientific research & teaching in many of the state universities has been declining over the years due to inadequate infrastructure and lack of sufficient number of committed scientific /teaching workforce. Though the numwerical challenges in terms of generation of quality PhDs are daunting, concern has been expressed over and over again that India must invest substantially in higher education embedded with quality research. Special assistance scheme which include creation of person or discipline based centres of excellence, upgradation of R&D infrastructure and floating faculty scheme has been suggested to rejuvenate the crumbling research base in state universities. Emphasis will also be laid to promote research in emerging, critical and thrust areas.

CSIR is supporting about 6700 Research Fellows and Associates (JRF NET, SRF NET, SRF Direct, SRF Extended, RA, and JRF GATE) and about 900 Research fellows in Research Schemes. Since the number of fellows being supported by CSIR is quite large, it is proposed to enhance the Fellowship budget under the above schemes.

Financial Resources projected for the Eleventh Plan

(Rs. crores)

	Name of the Scheme	Amount
1	CSIR Programme on Youth for Leadership in Science (CPYLS)	8.00
2.	Technological Entrepreneurship Programme for Research Scholars	8.00
3	Trans Disciplinary Fellowship Scheme	14.00
4	Shyama Prasad Mukherjee Fellowship Scheme (SPMF)	16.00
5	Faculty training and motivation and adoption of schools and colleges by CSIR laboratories	50.00
6	Research Fellowships in Basic Sciences & Interdisciplinary areas	870.00
7.	Conduct of JRF NET & SPM Examination	20.00
8	GATE qualified Junior Research Fellowship(JRF-GATE) Scheme	50.00
9.	Adjunct / Visiting Scientist Scheme for CSIR Labs (being formulated)	6.00
10.	CSIR - NIF Innovation Fellowship Scheme	3.00
11.	Setting up of Centres for Knowledge / Innovation / R&D / Technology Management	40.00
12.	Training program on Knowledge and R & D Management	10.00
13.	Special assistance scheme to promote research in universities	50.00
14.	Floating Faculty Scheme	45.00
15.	Project Interns Award Schemes for CSIR Labs	200.00
16.	Research Schemes in Emerging, Critical & Thrust Areas	100.00
Grand Total :		**1490.00**

3.4 INTELLECTUAL PROPERTY & TECHNOLOGY MANAGEMENT

Post-WTO, the country has emerged as an aggressive player on diverse aspects of Intellectual Property Rights (IPR), Innovation and Technology Management. During the period 1995-2005, India has complied with TRIPS obligations in various stages starting from providing mailbox applications in 1999 with retrospective effect from 1st January 1995 followed by second amendment in the Patents Act which was passed by the Parliament of India in 2002 and came into force on 20th May 2003. This amendment for the first time made our Patents Act more or less at par with the developed countries in providing a 20 year patent term, 18 months publication and also safeguarding national interest by remodeling compulsory license provisions and by introducing Bolar and Import Provisions. The third amendment in the Patents Act came into force from 1st January 2005 providing product patenting in pharmaceuticals, food and chemicals, rationalizing and reducing timelines for processing of patent applications and doing away with EMRs. The amended Act also provides with pre-grant and post-grant oppositions and also safeguards the generic producers from patent infringement suits by providing protection through EMR only from the date of grant. The other issues that are being debated in the country include data exclusivity, i.e. providing protection to clinical data in a sui-generis mode or through patent term extension, membership to WIPO Internet Treaty, Law on Optical Disc Treaty and enforcement of IPRs. The country has also enacted IP laws covering Geographical Indications, Biodiversity, Plant Varieties and Farmers' Rights and Layout Design of Integrated Circuits. The IP Acts covering Designs, Trademarks and Copyrights have been updated to be TRIPS compliant.

During the Tenth Five Year Plan period (TFYP), the systems of innovation comprising R&D organizations, universities, firms and individuals have contributed to the creation and protection of new products and processes through the instruments of IPR. The patent filings by Indians in the country have increased from a stagnant figure of about 1000 in the pre-WTO period to nearly more than threefold by 2003-2004. Such an increase is registered after 30 years. Similarly, the patent filing by foreigners in India has also increased substantially to a level of more than 9000 patent applications reflecting increasing interest by the foreigners in the Indian economy.

Proposed Programmes

CSIR under the Eleventh Plan will meet the challenges of IPR by : Selecting PPPs & R&D Projects based on sectoral IP trends and Developing linkages through IP creation, protection and diffusion. In addition continued efforts will be made to promote IPR through patent awareness and human resource development, patent acquisition portfolio, IP analysis as tool, promoting techno-prenuership, and support to industry for innovation.

Encompassing the above, the programmes proposed for the Eleventh Five Year Plan are listed below:

Filing, capturing, prosecution and maintaining of IPR for CSIR R&D outputs

Unlike in the Tenth Five Year Plan, focus now will be on to file only commercially and strategically important inventions to be protected nationally and internationally not withstanding the small number. This will be the major activity of the scheme during

Eleventh Five Year Plan. During EFYP, around 200 Indian patent applications and corresponding foreign patent applications widely covering inventions related to strategically important technologies in a market of emerging economies will be filed each year. At laboratory level opportunity analysis would be carried out for all the inventions. Analysis of IP, i.e. what needs to be protected is to be done at laboratory level and at the initial stages. Commercial viability will be ensured by stronger IP protection. Reactive to proactive IP protection, i.e. instead of filing what comes by way of routine, i.e. random patenting to planned patenting, i.e. designing patenting portfolios based on business plan with commercial and strategic considerations will be the strategy.

The activities, thus, cover the framing of the techno-legal-commercial patent application as per the requirements of the different countries, prosecuting these to secure the IP rights and subsequently safeguarding and maintaining the property. As foreign intellectual property rights are to be acquired, the foreign exchange component will be the major component of this expenditure. The envisaged expenditure for this activity would be around Rs. 208.00 crore

Valuation and valorization of patent and IP portfolios

This is a highly specialized activity and would be 'outsourced' initially with concurrent building up of organizational learning and expertise. Valorization in India will be done by CSIR but abroad, it would be cost effective to outsource this activity as CSIR does not have any outlets abroad and also lacks familiarity with diverse national laws, regulations and practices. As most of the expertise is presently not available in India, the major expenditure too would be in foreign exchange. For patents to be effectively used as tools for business , i.e. technology backed by patent wherein the patents should be of commercial value, the IP would be non porous and well protected in countries especially in emerging international markets. Mechanism to sell patents would be developed. An expenditure of Rs. 6.00 crore is anticipated for this activity.

Surveillance for infringement and enforcement of IPR

Like any property, IP also needs constant vigil and surveillance to check for infringement, unauthorized use, validation and violations and to take causative action for its enforcement. Since substantial intellectual property will accrue abroad – the surveillance of infringement will need to be taken up abroad. At Laboratory level increased contributions would be made towards the project management process with particular emphasis on potential customers perspective, particularly assuring non-infringement of IP. Policing of patents will be given special attention. Necessary software/tools for this purpose would be evaluated and procured. The estimated expenditure towards this activity would be of Rs. 6.0 crore.

Human Resource

Expertise and manpower in IP arena may not be readily available, hence bright-minds would be identified through in- house training or recruitment. There is a strong need for enhancement of manpower. Also clustered expertise needs to be developed both for IP protection and business development with trained staff both permanent and temporary and supported by certain assignments, if required. At present, each lab has separate groups like business development and IP cell. There is a need to remodel these groups so that there is a close interaction between these groups. IP cells needs to be strengthened at Lab level to carry out opportunity analysis. Necessary mechanism be adopted to facilitate interaction between CSIR labs & international agencies with a view to enhance advance level training under HRD programme. The expenditure of Rs. 3.00 crore would be required for this activity.

Modernization of computing, communication and related facilities and infrastructure

There is a need to remodel the existing IP cell at lab level and also HQ level for which additional infrastructure would be required. There is also need to upgrade the extant facilities to be able to digitally interact and transact massive 'patent files' globally to optimize on time and transaction costs. The expenditure also reflects the capital expenditure on computing and other communication facilities for supplementary manpower. The expenditure envisaged for this purpose will be around Rs. 7.0 crore.

Financial Resources projected for the Eleventh Plan

(Rs. in Crore)

Activity	Amount
Filing, capturing, prosecution and maintaining of IPR for CSIR R&D outputs	208.0
Formation, valuation & valorization of Patent & IP portfolios	6.0
Surveillance for infringement and enforcement of IPR	6.0
Human Resources	3.0
Modernization of computing, communication and related facilities, infrastructure	7.0
Total	**230.0**

3.5 R&D MANAGEMENT SUPPORT

CSIR headquarters, through various functional Units/Divisions provides the R&D management support and common and unified infrastructure to all its National Laboratories. As stated in Chapter 1, the Headquarters functions as the nerve centre for the organization and catalyses and facilitates the laboratories by establishing, equipping and realizing excellence in R&D, promoting brand equity, financial self-sufficiency, global competitiveness and disseminating organizational learning. The objectives of R&D management support are well defined in Chapter 1 and CSIR for meeting the R&D Management Support objectives formulated following activities during the Eleventh Five Year Plan.

R&D Management Support Schemes

Early-Stage Venture Fund (ESVF)

In India there is a lack of support for the early stage funding for the new products, process or technology to go into the market. Due to the present situation many enterprises are not coming forward to take the new products or processes being developed at various research institution particularly publicly funded organizations. As a result many new products or processes will remain in the shelf and become obsolete over the time incurring loss to the government. This necessitated the need of ESVF for an enterprise or new entrant who could build sufficient credibility to be able to go to commercial venture funds for additional money.

During the Eleventh Five Year Plan CSIR proposes to launch the scheme of ESVF for the entrepreneurs who come forward to commercialize and market the products and process developed by CSIR. This activity will be jointly carried out by DSIR and CSIR. Preference shall be given to the new entrepreneurs and CSIR scientists who can take challenge and risk in the market. The ESVF will be in the form of assisting the units being incubated in CSIR laboratories to grow to the point of commercial viability.

CSIR Chairs of Excellence

CSIR's niche operational domain extends to almost all areas of Science & Technology; its recognized strength being in the areas of Chemical, Biological, Materials, Engineering, Leather, Energy sectors to name a few important ones. In addition, CSIR has been at the forefront, rather at the top, amongst all national institution in technology generation and dissemination in various areas of its mandate. Over the years, this all has given it a global recognition wherein its contributions both in basic as well as applied areas have placed it in the higher echelons of performance driven apex scientific bodies.

CSIR's mission statement "To provide scientific industrial research and development that maximizes the economic, environmental and societal benefit for the people of India" enjoins its scientific research developmental activities to be directed towards technological developments and applications that maximize the overall benefits for India. It is appropriate now that we institutionalize a process wherein a systematized study on Indian R&D contributions in general and CSIR contributions in particular in the aforesaid areas are documented, critically analyzed, lessons drawn and use the resultant R&D indicators for S&T policy formulation. To facilitate that, it is proposed to institute 6 Chairs of Excellence, one each in the areas of Chemical Sciences, Biological Sciences, Material Sciences, Leather, Engineering and S&T Planning. These Chairs would be located in CSIR institutions and occupied by Scientists/Technologists of eminence to be selected through a process of invitation or nomination. Such incumbents would be provided honorarium and contingencies commensurate to the expectations – which are indeed high - to work. The incumbents could also chose to work on related theoretical aspect of R&D area specific to the Chair. The Chairs are proposed to be created and named as :

1. Bhatnagar Chair of Excellence in Chemical Sciences.
2. Thacker Chair of Excellence in the area of Physics & Engineering Sciences
3. Atma Ram Chair of Excellence in Materials Sciences

4. Hussain Zaheer Chair of Excellence in S&T Planning, Technology Generation, Diffusion and Management
5. Sidhu Chair of Excellence in Energy
6. Nayudamma Chair of Excellence in Biological Sciences

CSIR Centres for Sustainable Growth

CSIR has a history of more than 60 years of research and development and the resultant technological achievements behind it. It would not be an exaggeration to say that the entire science and technology advancement in India has been spear-headed and driven by CSIR, specially in the first few decades after independence. Many of its 38 laboratories are known globally for the quality of research output, be it the processes or products or addition to basic understanding of the domain knowledge. Many of these laboratories have builtup a culture of excellence, the growth catalyst, in the niche domain of their working which provides and nurtures the growth of these laboratories. It is this culture which sustains an institute over a long period of time – churning out fresh ideas, developing them and ploughing the knowledge thus gained, back into the system for future growth. We need to plan and firm up such organizational culture to stay relevant by creating CSIR Centres.

These Centres would serve for twin purposes towards sustainable growth – one as an overarching R&D enabler for all the projects within the institution, a kind of melting pot around which the core competency of the particular institution could be built; and the other a mechanism to attract the best talent from outside the institution by offering them the world class ambience both in terms of men and material and also a kind of residential think-tank to plan and execute futuristic and disruptive projects which shall propel CSIR to leap-frog, augmenting and sustaining its strength in core R&D domains.

It is therefore, proposed that in the Eleventh Five Year Plan a few CSIR laboratories would create such Centres which encompass their specific domains . In the initial years it is proposed to set up 20 such Centres which would provide state-of-the-art, globally competitive R&D facilities and challenging ambience.

These Centres would have arrangements to invite and provide working facilities for those scientists of Indian origin who are willing to lend their skills to their motherland for an agreed time frame. A large number of talented Indian scientists like those of other countries are scattered around the globe many of which could easily link up with CSIR priority programmes. A platform to attract these talented Indian scientists and scholars working abroad to get involved in CSIR priority programmes is therefore in line with CSIR efforts to enhance national competitiveness in key areas. They would be offered facilities at par with, may be better than, what they are used to, to work on problems – both of basic and applied nature – appropriate to the Centre. Sharing credits for such work could be suitably structured. Such Scientists / Technologists of Indian Origin (STIOs) would be offered appropriate honorarium, boarding facilities and so on. An annual intake of 100 STIOs is proposed in this Plan period.

Yet another aim of these Centres would be to attract bright young students/trainees to work and also get trained for a fixed period of time in scientifically challenging and industrially relevant projects. This would facilitate development of human resource that would eventually be capable of working on or to utilize available knowledgebase to convert that into wealth and also help generate new knowledge and innovations. This would also greatly help our R&D institutions to overcome the deficit of trained students/staff. For proposing such a scheme, operative in CSIR laboratories will mean a substantial investment. However, such an investment now will eventually give us an edge by making available a large pool of focused and trained manpower, necessary to sustain performing organizations like CSIR.

An annual intake of more than 500 students shall be planned for all such Centres. Stipend/fellowship shall be fixed as per organizational norms. It is proposed to earmark Rs. 250 crores for this scheme for the plan period.

National Innovation Foundation

National Innovation Foundation (NIF), constituted by the Department of Science & Technology, Government of India aims to recognize, respect and reward grass roots technological innovators and traditional knowledge experts. It is mandated to build a National Register of green grass roots technological innovations and traditional knowledge practices developed by various individuals and communities in the unorganized sector. CSIR has entered into an MoU with NIF with objectives of empowering grass root innovators, who have developed the ability of creativity and innovation by blending formal science with informed creativity and innovation in the areas of mechanical engineering, energy, food & herbal value addition.

CSIR laboratories take up the innovations selected by NIF and recommended by a Joint Implementation Committee (JIC) for validation/value addition. During the Tenth Five Year Plan, ten projects under different areas were supported under the scheme. CSIR would further developing joint projects for validation and value addition in the Eleventh Five Year Plan.

New Idea Fund

Council of Scientific & Industrial Research has an ongoing 'New Idea Fund' scheme through which support is given to test and validate novel and highly creative ideas, even if they have a high probability of failure. These proposals are of exploratory nature and are supported under the scheme for proving the feasibility of possibly far-reaching concepts. Till recently, the scheme was open only to CSIR scientists for support. Based on its initial experience, the scope of the scheme has been widened to incorporate joint proposals between CSIR laboratories on one hand and scientific institutions or universities on the other. During the Eleventh Plan the scheme will be further modified and involve demand driven proposals wherein grand challenges will be given to a group of aspirants.

Human Resource Development Centre

Established in 2002 with a major objective in conducting training programmes broadly in the areas of induction, orientation, refresher and skill up-gradation training programmes for different categories of CSIR staff. In addition to these number of programmes are conducted in specialized areas such as Technology Management, Research Methodology, training on Management like; implementation programme on ISO 9001:2000, QMS certification, development of Management Information System (MIS) for various HR activities, Training

Need Analysis (TNA), e-training etc. have also been implemented. CSIR will continue the present activities of HRDC in the Eleventh Five Year Plan to benefit large number of its staff.In the Eleventh Plan a budgetary support of Rs.50 crore is projected under this activity.

Realizing that in this knowledge economy era there is a need for the creation of larger numbers of high quality specialized scientific human resource especially in the Trans-disciplinary areas, CSIR in the Eleventh Five Year Plan proposes to expand the scope of HRDC under a registered autonomous society named CSIR-Advanced Institute of Science Training (CSIR-AIST) within CSIR premises. The establishment of CSIR-AIST with a deemed University status has been put forward. It is emphasized that CSIR's Extra Mural Research will continue to support Universities in research as before and also the local support to the Universities will continue.

The Deemed University status to CSIR-AIST would give impetus to CSIR to produce specialized scientific human resource in selected frontier areas, to take up scientific industrial research as career. The opportunity to work on the frontier and inter-disciplinary areas will attract the best of the young minds and hopefully prevent the brain drain with a direct benefit to the nation. The Science of today is integrative and trans-disciplinary. One of the objectives of CSIR-AIST deemed to be University is to encourage transdisciplinary research and it would be possible for a student working on the identification of drug using *in-silico* Biology with a supervisor in one of the participating laboratories and a co-supervisor in another participating laboratory to register for his/her Ph.D. Similarly, a student with a B.Tech. degree will be able to change the subject and switch over to a Ph.D degree in, say, Life Sciences for working on Bioinformatics, Neural Network, Nanobiotechnology, etc.

India has well developed higher education system which has served us well so far but in the present global scenario there is a need of quality and trained manpower in the field of science & technology. The higher education institutions are finding it difficult to get quality manpower to carry out R&D in science and technology resulting in huge gap between the demand and supply. Unless we provide quality manpower in S&T we will run in to skill constraints which will limit our ability to exploit this important area of competitive advantage. To augment this CSIR is proposing CSIR-University R&D centres for excellence where universities would have access to state-of-art infrastructure and expertise available in various CSIR laboratories to enable universities to generate quality manpower in frontier areas of S&T. Under the Eleventh Five Year Plan a budgetary support of Rs.100 crore is proposed for CSIR-University R&D centres of excellence.

R&D management and Business development

The Eleventh Plan projects call for adoption of professional management practices due to their overarching network complexities, and trans disciplinary areas, linkages within and outside CSIR, i.e large number of partners, optimum utilization of resources and timely delivery of the outputs. Therefore, there is a need to adopt modern project management techniques and tools of international standards. Similarly there is an increase in the number of PPP programmes over the Tenth Plan, which demand for application of new business models and management practices. The achievements of past years and CSIR's adoption of good management, laboratory and IP protection practices have led many of its laboratories to establish linkages with well-known global pharma giants. Such linkages need to be nurtured and sustained through regular contacts and interactive sessions, nationally and internationally. Thus R&D Planning and Business Development Divisions of CSIR headquarters and laboratories need special emphasis on training, establishing and nurturing linkages and also bringing in good management practices both at national and international levels. To support activities of R&D planning and business development a budgetary support of Rs.50 crore is proposed in the Eleventh Plan.

International Scientific collaboration

India is galloping on the track of prosperity. Regularly enhancing per capita availability of food, money, education, health, and global respect are its indicator. A major contribution to this has come from our strides in S&T such as in space, IT, health, pharmaceuticals and so forth. India appreciates that the engines of economic and human growth operate on the fuel of world-class S&T. Expanding frontiers of our knowledge, its ramifications and the need for infrastructural plus ideological resources beckon the necessity of international collaboration, especially in R&D on cutting edge technologies.

Most of the spectacular technologies / disciplines such as MEMS, CNT, fuel cells, post-genomic medicines, bioinformatics, thermonuclear experiments, mining under the oceans, disaster management have necessarily inculcated multi-institutional and multinational efforts on a global scale in a joint and sustained manner. Substantial augmentation of infrastructure and R&D efforts are being undertaken by CSIR and its strengths coupled with a suitable planned international collaboration would offer it a challenge to absorb and undertake globally as well as industrially relevant R&D. The sectotal approach adopted would get focused for some of the international collaborations.

In addition several new instruments of cooperation at the general level are also proposed to be created along with ongoing programmes from the previous plans. These new instruments of cooperation will cut across several disciplines and complement the sub-groups' activities. The proposed new instruments of cooperation in the next five-year plan include the following:

1. Travel Grants Scheme for Conference Participation of CSIR Scientists aboard.
2. Internship Scheme for Foreign Students
3. Distinguished / Senior Foreign Scientists Awards
4. Fellowships for Scientists from Developing Countries
5. Industry Co-sponsored CSIR Knowledge Partnership Awards
6. Participation in international consortium projects
7. Creation of international centres of excellence for collaborative projects in CSIR laboratories
8. Creation of FAB labs and co-operation with MIT Institute, USA for digital fabrication

The above instruments of cooperation have been pursued in the previous plans as stand alone activities in varied forms without sharp and clear articulation. In the Eleventh Plan CSIR would pursue these programmes with a clearly defined objectives to provide appropriate opportunities to CSIR scientists zeal to maintain global standards.

These instruments of cooperation will be tailored to achieve the following with definitive targets

- Attracting eminent and distinguished foreign scientists to CSIR both from developed and developing world.
- Attracting senior foreign scientists to CSIR both from developed and developing world.
- Attracting foreign scholars for research and training in CSIR laboratories
- Creating opportunities for CSIR scientists for conference participation abroad
- Developing networks and twinning arrangements for CSIR labs
- Creating opportunities for CSIR scientists to become knowledge partners for Indian industry while availing fellowships abroad

CSIR's international cooperation activities have hitherto been pursued through a range of programmes. Many of these would need to be continued along with the newer programmes and modalities described above. These ongoing programmes are described below:

- S & T Cooperation with other countries through bilateral agreements
- Travel grant for non-CSIR Scientists
- Raman Research Fellowship abroad to CSIR Scientists
- UNU Fellowship for Developing Countries - UNU, CSC Fellowships for researchers from developing countries
- CSIR-TWAS Fellowship for developing countries
- CSIR / COSTED Young Scientists Foreign Travel Scheme
- Contribution to NAM S&T Centre
- Development of database, networking and maintenance of WebISTAD
- Global Research Alliance

Science Dissemination

Several brand image building activities were undertaken during the Tenth five Year Plan. Some of them are given below:

- Image building through print media includes press coverage and press conferences of various important occasions like Bhatnagar Awards Function, new product launching, Diamond Jubilee Awards, etc.
- Image building through broadcast media
- Image building through interactive media (Exhibitions, Trade Fairs etc.), i.e to creating awareness about CSIR & its achievements, and supporting CSIR's business development efforts.

CSIR would strengthen its present image building activities and evolve new strategies in the Eleventh Five Year Plan.

Financial Resources projected for the Eleventh Plan

Sl.No.	Activity/Head	Rs. in crore
1	**R&D Management Support Schemes**	
	Start-up Venture Capital	25
	CSIR Chairs of Excellence	50
	CSIR Center for Sustainable Growth	250
	National Innovation Foundation	25
	New Idea Fund	50
2	**Human Resource Development Centre**	50
	CSIR-University R&D centres of excellence	100
3	**R&D Management and Business Development**	50
4	**International Scientific collaboration**	200
5	**Science Dissemination**	50
	Total	**850**

3.6 NEW MILLENNIUM INDIAN TECHNOLOGY LEADERSHIP INITIATIVE (NMITLI)

During the Tenth Plan NMITLI has created a brand image and is viewed today as a benchmark of PPP schemes which is being emulated by various other government departments. The partners especially from the industry, were of the view that industries which partnered NMITLI projects have highly benefited not only in terms of the hard objectives and achievements in the project wherein they participated but also in terms of other associated gains such as high quality technical inputs etc. As India is entering into a new era of R&D, more such newer approaches of innovation development need to be evolved and experimented. In this context it is proposed to expand the programme with new approaches of innovation development. Following are among other concepts to enlarge under NMITLI:

- Pre and post NMITLI
- Funding with industry (50:50 Initiative)
- Co-financing with Venture Capital funds
- Long term sustained efforts in selected areas (NMITLI innovation centres)
- Acquisition of early stage relevant knowledge / IP for portfolio building.

CSIR has introduced many structural changes to increase the effectiveness of the programme. During one of the NMITLI review meeting following were recommended to consider in the programmes:

- Relaxing compulsion of industry partner for projects in strategic sectors / select areas
- Relaxing the condition of more than 50% shareholding by Indians/Non-resident Indians
- IPR sharing
- Flexibility to convert loan into equity
- Financial incentives to investigators in public domain and scientists managing the programme.

NMITLI IN XI FYP

In the XI plan, NMITLI programme will be expanded with diverse newer initiatives so as to further build on innovation driven technology niches for economic and industrial development of the country on one hand and to explore and develop newer approaches for R&D led innovation on the other. This would enable the NMITLI programme to broad base its developments in the innovation and thereby move the whole programme to a much higher level. The new initiatives would include: (i) pre and post NMITLI; (ii) setting up of NMITLI innovation centres in identified areas; (iii) putting in place 50:50 initiatives; (iv) co-financing projects along with venture funds; (v) acquisition of early stage relevant knowledge / IP with a view to building portfolio. These proposed new initiatives are briefly explained below.

Pre and post NMITLI

It has been experienced after execution of the NMITLI for seven years that the country lacks infrastructure and intellectual base for mounting projects in many cutting edge, nascent and emerging areas. The current milestone based format and limited duration of NMITLI projects do not leave much scope for venturing into such areas. NMITLI had to drop few projects during development and forgo another few because of these reasons. Therefore, in order to undertake exploratory projects in such areas, it is proposed to introduce the concept of 'Pre-NMITLI'. These would cover new and identified areas as well as individual proposals. The projects under this program would create a 'feeder line' for providing new ideas, intellectual base and infrastructure for milestone based and technology / product oriented NMITLI. These projects would be developed and monitored on the same lines as that of NMITLI vis-à-vis pre-defined objectives without excessively emphasizing on technology development.

Similarly, it has been felt that a critical gap exists between the level of technology / product developed under NMITLI and its commercialization. The government has to walk an extra mile to see the technologies / products developed under the program reach to the intended beneficiaries. The concept of 'Post-NMITLI' is being proposed to fulfill this objective. The projects under 'Post-NMITLI' would provide financial and technical assistance to industrial partner for scale up, pilot plants, field trials, market surveys, pre-commercialization, market seeding etc. The proposed assistance to industry would be in the form of soft loan.

Setting up of NMITLI innovation centres in identified areas

Certain areas need critical mass of resources (human as well as infrastructure) assembled at one place to cross the threshold of intellectual barrier in order to generate high quality publications, IPR, technologies and products. The scattered infrastructural and human resource capital, even if available has not led to any worthwhile discoveries in those areas. Even the cherished networking of NMITLI would not be very effective in such cases because of lack of critical mass, besides creation of duplicate facilities at different locations. Therefore, it is proposed to set up 'NMITLI Innovation Centres' for sustained efforts in some selected areas for example, Seed Development, Photovoltaics, Vaccine development, Fuel Cells, White LEDs, Industrial Enzymes, Medical Implants etc

These centres would be set up at identified institutions either within CSIR chain of laboratories or public institutions under the control of other government departments. These centres would execute specific projects in collaboration with industry in Public-Private Partnership (PPP) mode.

Putting in place 50:50 initiatives

There are many Indian companies who are doing financially very well but do not have the necessary expertise and intellectual resources to develop focused network projects for development of technologies/products in their line of activities. Their efforts need complementation from suitable R&D institutions and guidance from recognized peers to develop and commercialize newer technologies/products. Therefore, NMITLI proposes to leverage its experiential base to encourage and assist such companies for developing network projects for those companies in product/technology development through a specific scheme, proposed to be called as 'NMITLI 50:50 initiative'. The projects will be maintained with same rigour as that of other NMITLI projects.

This initiative would be made applicable to all Indian or foreign companies having manufacture base in India, who are in possession of R&D leads or proof of concepts or willing to develop leads obtained elsewhere in public institutions. It is envisaged to provide 50% financial support from NMITLI and the rest 50% project cost would come from the company for development and commercialization of the technology/product. On successful commercialization of the technology/product, the company shall pay a royalty.

Co-financing projects along with venture funds

Many of the Venture Capitals such as ICICI, IVF are interested in joining hands with NMITLI to finance projects. Such projects would be identified and evolved following the procedures established by NMITLI. The funding would be joint with equal contribution from CSIR and Venture Capitals. These projects are envisaged to be monitored by a joint team of experts as per the NMITLI monitoring mechanism. The successes and failures resulting from the projects will be shared on equitable basis.

The proposed funding to the Indian industry would be in the form of soft loan with 3% simple interest. On successful commercialization of the technology/product, the company would return the loan along with interest in 10 installments. The incubation period will be the moratorium period and will not be liable for repayment of installments and interest.

However, the interest accrued during the incubation period will be amortized and will be payable in a maximum of 1 to 5 installments. A cess of 0.5% of sales turnover for a period of 10 years may be imposed on the industry. Money realized through the scheme may be recycled and utilized for funding new projects.

Acquisition of early stage relevant knowledge / IP with a view to building portfolio

Innovation is going to determine a country's global competitiveness in future. However it is not necessary to invent everything in-house. External ideas / leads / IP acquisition are assuming greater significance in the chain of innovation and mind to market. The availability of a large number of unencumbered IP (being developed in several laboratories globally) is providing a fillip to this approach. Thus, several countries across the globe are striving to take advantage of the diversity of creativity available in different parts of world and integrate with its own developments to bring out new products / processes for global competitiveness.

XI PLAN OUTLAY

Keeping in view the new initiatives being proposed, the budget requirement for the programme in the XI FYP would be of the order of Rs.1200 crore.

3.7 SETTING UP OF INSTITUTE OF TRANSLATIONAL RESEARCH

Recently, there have been many technological breakthroughs, which have made it possible to analyze the genome at a scale that was unthinkable earlier. The emerging technologies of DNA chip/microarray, proteomics, comparative genomics, structural biology, bioinformatics and gene knockout will help in determining the function of most of the genes and understanding their interaction with environmental factors and relationship with the human behaviour. This knowledge would be useful towards amelioration of human suffering by discovery of new drugs using transgenic animal models for human diseases. Extensive collaboration amongst clinicians, epidemiologists, geneticists, mathematicians and computer experts will be required to solve this puzzle and the genetic underpinning of complex diseases that affect the lives of millions.

Any amount of scientific skill and money cannot compensate for the availability of human genetic diversity and unique and large number of clinical samples. India is one of the largest in human genetic diversity. It has as many as 4694 anthropologically well-defined endogamous populations, many of them are highly resistant or susceptible to different diseases. With rapid urbanization, it is not uncommon to see large number of different ethnic or anthropological groups in big Indian cities such as Mumbai and Bangalore. Indian population also constitutes 427 different tribal groups, many of whom have not adopted modern civilization and they live without the intervention of modern medicine. Due to these factors, India stands unique in studying gene-environment interactions in the manifestation of a disease and exploitation of the same for developing personalized medicine.

Action Plan

Biological/clinical research is increasingly becoming interdisciplinary. At the same time, translational research/stem cell research etc need focused attention of scientists from different fields. A new institute dedicated to carry out such work *in mission mode* would be more productive than trying to network scientists with diverse interests from different cities.

The proposed institute and the associated medical school would be established in one campus. If the proposed translational research centre and the medical school are established in the same campus, a systematic approach could be adopted right from the beginning to enable better interactions between clinicians and the researchers. This is a required element to work on any project in a mission mode.

The institute will provide:

1. Strong interacting team of clinicians, statisticians and molecular biologists.
2. Laboratory and associated hospital complexes
3. State of the art Laboratory for cell and tissue engineering
4. Highthroughput facilities such as genomics (microarray, sequencing, real-time RT-PCR) and proteomics facilities and NMR-spectroscopy and NMR-microimaging facilities.
5. Dedicated lab for developing RNAi-based therapies
6. Gene banks, cell lines (from clinical samples), tissue arrays etc and *Drosophila*, *C elegans*, Zebrafish, mouse genetics lab facilities.
7. Nanotechnology lab for developing necessary nanomaterials for the research in the area of stem cell biology as well as for clinical applications.
8. Both Ph.D. and MD Ph.D. programmes.

Expected outcome

- Application of knowledge of modern biology into clinical care. The driving force here is to help Indian hospitals and clinicians in providing better healthcare by bringing the knowledge of genomics to patient's beds.
- Systematic collection and analysis of large amounts of clinical data. This exercise would give us more information on the epidemiology of a disease by way of allowing us to work out correlations.
- Development of ways and means of Personalized medicine: Despite major advances in drug development, more often than not, patients do not respond favourably to a drug. Judicious exploitation of genomics and proteomics technologies is expected to provide ways to develop pharmacotherapy for each patient based on individual's genetic profiling. These studies would eventually lead us to "personalized medicine", which is expected to reform the medicine in coming decades.
- Development of specific stem cell populations to treat a variety of illnesses such as Parkinson's disease, Type I diabetes, retinal degeneration, myocardial infarction, spinal cord damage, multiple sclerosis and many others.
- Molecular diagnosis: Development of new diagnostic markers/tools/methods and providing the services of the same and genetic counseling.

- In addition, we expect several new technologies/products arising out of this mission-mode project. Some of the allied technologies that may take off from the proposed initiative are,
  - Development of nanomaterials (of both biological and non-biological origin) for cell and tissue engineering
  - Nanostructured implantable materials
  - Design and development of targeted gene delivery systems.
- By innovative initiatives such as Genome Foundation (a foundation dedicated for spreading genomic knowledge to the rural India), we would *take the fruits of our efforts to the rural and under privileged populations*.
- Training would be a major component to generate adequate manpower for the country to set up more such institutes and to excel in this field.

Successful completion of these studies will fulfill our mission of changing disease management from its current status as an art to more of a science.

Financial Requirement

When fully functional the institute will have ~200 scientists/clinicians and ~450 other technical and administrative staff + ~300 students. A budgetary support of Rs.1000 crore is projected for the Eleventh Five Year Plan.

CHAPTER-4

FINANCE

4.1 INTRODUCTION

Government of India, through successive plans, has provided enhanced and substantial budgetary support to CSIR. From a budgetary support of Rs.4.67 crore during the first plan (1951-56), it has gone up to around Rs.6413 crore for the Tenth Plan **(Table I)**. This support from the Government has enabled CSIR to establish R&D Laboratories/Institutes in diverse areas of Science & Technology and helped it to serve the society and industry. Many of its laboratories are now globally known for the quality of research outputs, products and processes. Institutes of CSIR have set up Centers of Excellence in their niche domain of working. CSIR provided a critical mass in getting India identified as an Innovating Developing Country based on its contribution in Intellectual Property Management. CSIR has emerged as a dominant player in IP arena moving ahead or close to its counterpart organizations worldwide. The support has enabled CSIR to become a formidable global R&D player. CSIR, thus, acknowledges its appreciation for the continuous enhanced support from the Government.

4.2 FINANCIAL PERFORMANCE DURING THE TENTH PLAN

CSIR, in addition to the budgetary support from the Government derives its finances from two other sources, namely (i) from Contract R&D and (ii) Internal Receipts.

For the Tenth Plan, the Planning Commission had approved an allocation of Rs.2430 crore as against a request of Rs.4545 crore. The anticipated plan expenditure for the Tenth Plan is of the order of Rs.2976 crore. The Non Plan anticipated expenditure during the same period is of the order of Rs.3437 crore. The scheme wise breakup of expenditure is provided in **Table II**. The percentage distribution of allocations under different schemes is also shown in **Chart I.** CSIR is expected to generate an external cash flow (ECF) of the order of Rs. 1590 crores from contract R&D.

CSIR has brought to the fore, in a major way, the networking competence of its laboratories during the Tenth Plan and has worked with 56 Network Projects. The experience has been rewarding, in terms of synergizing the diverse strength earlier sub-optimally utilized by different laboratories to address the newer R&D goals. These projects were grouped into the socio-economic sectors of relevance to CSIR's working. While most of the projects would be completed during the Tenth Plan, some of the projects **(Table III)** will spill over in the Eleventh Plan due to late start of the projects. During the period, CSIR has also provided financial support for the civil infrastructure, renovation on a selective basis, R&D Management Support to the laboratories, National S&T Human Resource Development. Under the two major schemes of the Tenth Plan, namely Intellectual Property & Technology Management and New Millennium Indian Technology Leadership Initiative their envisaged objectives for the Tenth Plan would be achieved. The scheme on ICT Infrastructure, Renovation however, due to late approval from the Government, will spill over to Eleventh Plan.

4.3 STRATEGY FOR XI PLAN

Network mode has become a part of the CSIR working during the Tenth Plan and is aimed to be strengthened manifold during the Eleventh Plan. A substantial additional resource inputs would be needed to make this happen. The laboratories would have to be refurbished and modernized through project selection and implementation. Knowing, the budgetary constraints with the Government, new ways of financing, mobilizing and managing the requisite resources would be explored to supplement the budgetary support from the Government. The targeted external cash flow during the Eleventh Plan would depend upon the budgetary support, however as a percentage to the budgetary support CSIR would attempt to generate 30%.

In order to enhance the level of productivity and optimize on the return from investment, utmost care would be exercised to incur the expenditure effectively, efficiently and economically and in a transparent manner in tune with higher level of performance standards. A vigorous review and modern project management practices would be put in place to ensure envisaged outputs and outcomes are achieved in the given time frame. The budget allocation to the laboratories would be on project base and performance oriented through a set of agreed Science & Technology Performance Indicators. The tested Project Management and ERP tools would be used for managing these projects.

The Planning Commission has envisaged a growth rate of 8.5% for the Eleventh Plan. To achieve the socio-economic objectives of the Eleventh Plan, S&T tools shall have to occupy a central place in the developmental strategies. India has created a very large number of capabilities in S&T but our system, institutions and also major areas of national development have not been largely receptive to the concept of S&T based transformation to the extent needed. It is, therefore, desired that S&T gets integrated adequately with major areas of plan endeavours. CSIR, recognizing this, has charted out its entire activities linking with socio-economic sectors. For each one of them, during the Eleventh Plan, projects have been identified to be implemented in various modes and involving users & others in the innovation chain.

The planning process in CSIR has gone into a change mode and it would be stake holder and customer focused rather than agency centeric, linking inputs to outputs and outcomes. The implementation strategies would be agency centered rather than laboratory centered with assured responsibility and accountability and linking inputs to meet goals and targets. A third party outcome audit system would be introduced for internal alert and for mid - course correction. The outcome budget envisaged by the Government would be fully integrated as applicable to R&D organizations.

4.4 FINANCIAL RESOURCES FOR THE ELEVENTH PLAN

Plan

CSIR, on the basis of Zero Based Budgeting, will be merging the scheme on ICT Infrastructure under the National Laboratories and will operate five ongoing schemes with new components and programmes under each one of them. A new scheme of setting up of an Institute of Translational Research would be introduced in the Eleventh Plan. A Plan outlay of Rs. 17580 crore has been envisaged for the six plan schemes during the Eleventh Plan. Scheme-wise proposed plan support for Eleventh Plan is provided in **Table IV**. The enclosed **Chart-II** shows proposed distribution of allocations under different schemes for the XI Plan.

Under the National Laboratory Scheme, in the Eleventh Plan, CSIR would operate its programme in network mode, comprising 37 Supra Institutional Projects, 143 Network Projects, 18 Inter-Agency Projects and would also create 28 Facilities. The **Table-V** and **Chart-III** shows the project wise distribution of Eleventh Plan under National Laboratories. An estimated outlay of Rs. 12810 crores would be required under the National Laboratory Scheme which includes the on going component of Rs.600 crore, creating, nurturing and sustaining the core knowledge frontier of Rs. 1000 crores, scale-up & validation of leads developed in-house of Rs.500 crore, open source drug discovery programme for infectious disease of Rs.500 crore, laboratory modernization for eco-friendly sustainable growth of Rs.500 crore and Civil Infrastructural Renovation of Rs. 1000 crores. **Table VI** provides at a glance the sectoral distribution of outlay during the Tenth Plan and Eleventh Plan respectively for the schemes of National Laboratories. **Chart-IV & Chart- V** give a glimpse of percentage sectoral distribution of approved and proposed allocations under National Laboratories for the Tenth Plan and Eleventh Plan respectively.

Under the National S&T Human Resource Development Scheme, the major shift and focus would be to create fellowships in basic sciences and inter-disciplinary areas. In order to provide focused and sustained support, the scheme would be funded under the Plan and the Non Plan component would accordingly be reduced in five year period. The cost of fellowship is worked out based on the proposed enhancement of fellowship by DST as a whole, would require a budgetary support of Rs.1490 crore during the Eleventh Plan.

For Intellectual Property & Technology Management Scheme, budgetary support required would be Rs.230 crore during the Eleventh Plan for all its new activities as proposed.

R&D Management Support Scheme would seek a budgetary plan outlay of Rs.850 crore for various activities.

New Millennium Indian Technology Leadership Initiative Scheme in a public and private partnership mode would require a budgetary support of Rs.1200 crore, essentially for new initiatives to be taken in the form of NMITLI Innovation Centre.

The setting up of a Translational Institute would require a plan budgetary support of Rs.1000 crore under Eleventh Plan.

Non Plan

The non plan support would be provided to the scheme such as National Laboratories, National S&T, HRD and R&D Management support. The support would essentially to meet the committed liabilities on salary, pension and the maintenance of infrastructural facilities. On the basis of the liabilities an estimated Non Plan requirement of Rs. 7500 crore would be required for Eleventh Plan.

Table- I Government Grant to CSIR

(Rs. crore)

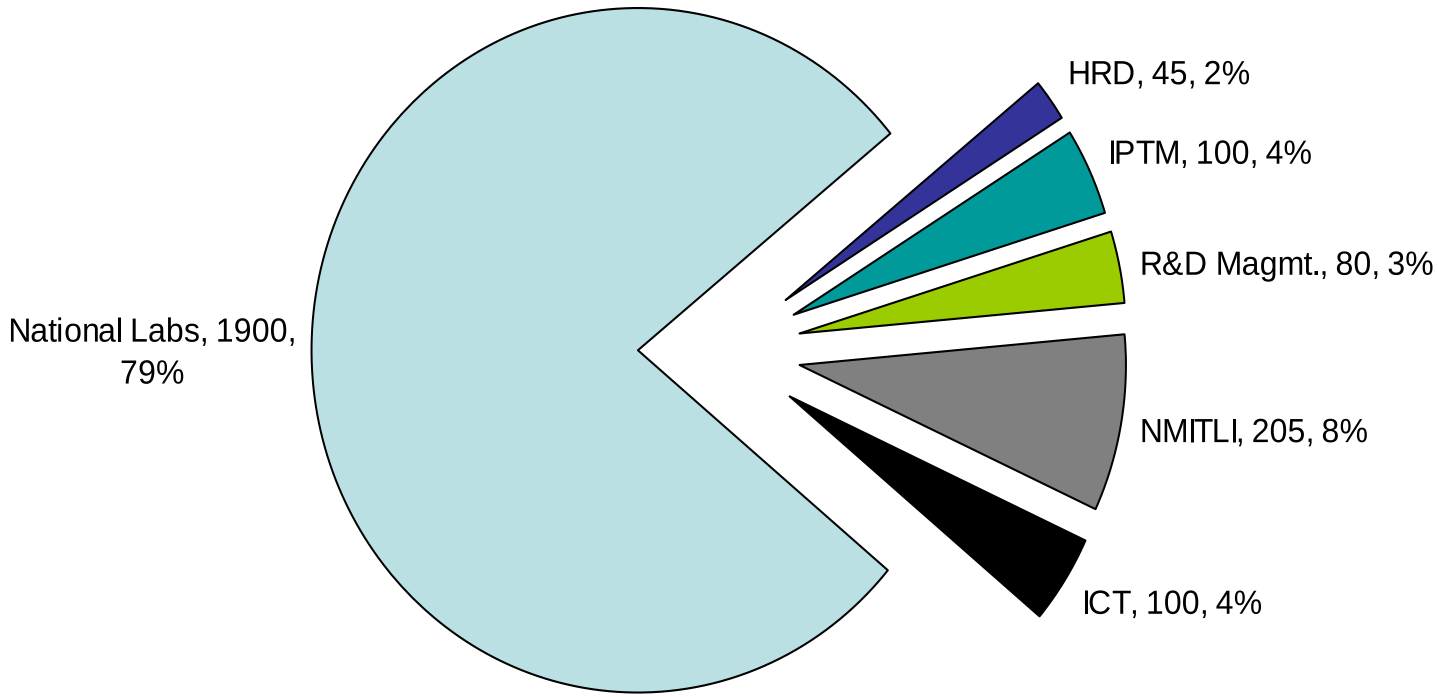
PERIOD	PLAN	NON-PLAN	TOTAL
1ST PLAN (1951-56)	4.67	0.00	4.67
2ND PLAN (1956-61)	14.58	6.97	21.55
3RD PLAN (1961-66)	33.34	21.59	54.93
4TH PLAN (1969-74)	37.46	71.41	108.87
5TH PLAN (1974-79)	54.25	104.96	159.21
6TH PLAN (1980-85)	216.91	232.24	449.15
7TH PLAN (1985-90)	359.09	548.01	907.10
8TH PLAN (1992-97)	703.00	1076.00	1779.00
9TH PLAN (1997-2002)	1356.00	2583.19	3939.19
10TH PLAN (2002-2007) (AE)			
Approved Outlay	2430	3437	5867
Anticipated Expenditure	2976	3437	6413
11TH PLAN (2007-2012) (Proposed)	**17580**	**7500**	**25080**

Table-II Utilisation of Tenth Five Year Plan Government Grant

(Rs. crore)

HEAD	2002-2007 Approved	2002-2003 Actuals			2003-2004 Actuals			2004-2005 Actuals			2005-2006 Actuals			2006-2007 Outlay			2002-2007 Anticipated		
		Plan	NPlan	Total	Plan	NPlan	Total	Plan	NPlan	Total	Plan	NPlan	Total	Plan	NPlan	Total	Plan	NPlan	Total
National Laboratories	1900.00	281.77	393.00	674.77	364.00	402.54	766.54	499.77	405.70	905.47	584.01	419.49	1003.50	735.00	432.25	1167.25	2464.55	2052.98	4517.53
National S&T HRD	45.00	5.00	52.53	57.53	5.00	67.00	72.00	5.00	97.00	102.00	5.00	104.00	109.00	10.00	104.50	114.50	30.00	425.03	455.03
Intellectual Property & Tech. Management.	100.00	15.00	0.00	15.00	20.00	0.00	20.00	5.00	0.00	5.00	30.00	0.00	30.00	40.00	0.00	40.00	110.00	0.00	110.00
R&D Management Support	80.00	10.00	151.65	161.65	10.00	175.00	185.00	20.00	183.00	203.00	15.00	217.00	232.00	15.00	233.00	248.00	70.00	959.65	1029.65
New Millennium Indian Technology Leadership Initiative	205.00	26.64	0.00	26.64	30.00	0.00	30.00	50.00	0.00	50.00	43.54	0.00	43.54	90.00	0.00	90.00	240.18	0.00	240.18
ICT Infrastructure Rennovation and Refurbishing	100.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00	9.00	0.00	9.00	50.00	0.00	50.00	61.00	0.00	61.00
TOTAL	**2430.00**	**339.41**	**597.18**	**936.59**	**429.00**	**644.54**	**1073.54**	**580.77**	**685.70**	**1266.47**	**686.55**	**740.49**	**1427.04**	**940.00**	**769.75**	**1709.75**	**2975.73**	**3437.66**	**6413.39**

Chart-I Distribution Pattern of Allocation in Xth Plan



Figures in Rs.crore & corresponding % to total

Table-III Ongoing Commitments from the Tenth Plan

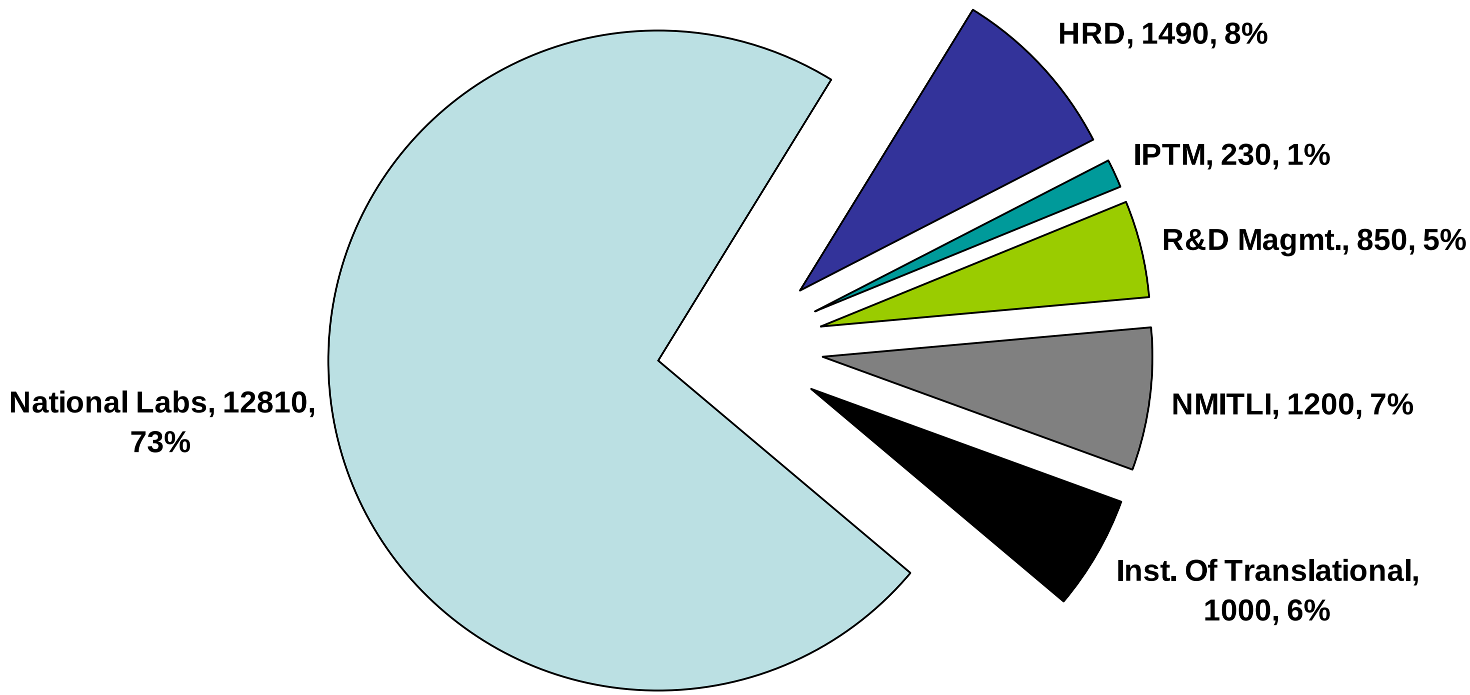
	Project ID	Title of the Programme	Spill over (Rs. Crore)
A.	**Steering Committee identified Network Programmes in Mission mode**		
1	SMM01	Spearheading small civilian aircraft design, development & manufacture (cost being revised)	150
2	SMM07	Newer scientific herbal preparations for global positioning	5
B.	**CSIR Working Group identified Network Programmes**		
3	CMM08	Acquisition of Oceanographic Research Vessel (ORV) for Oceanographic Research	160
4	CMM15	Setting up a world class drug research institute	150
5	CMM17	Drug target Development using In-silico Biology	5
6	CMM24	Upgradation of SI Base Units, National Standards of Measurements & creation of a network of Calibration and testing laboratories and preparation & dissemination of CRMs	15
C.	**CSIR Core Programmes**		
7	CORE01	Developing and sustaining High Science & Technology for National Aerospace programmes	45
8	CORE13	New and Improved Road Technologies	15
9	CORE14	Establishing National Science Digital Library (NSDL)	15
10	CORE19	Development of comprehensive technology for disaster prevention and management of Jharia coalfield	10
11	CORE23	Discovery, development and commercilisation of New Bioactives and Traditional Preparations	10
12	CORE17	Establishing Genetically Modified Foods Referal facility	10
13	CORE24	Setting up of National Facility for advanced proteomics research	10
		Total	**600**

Table-IV Proposed Plan Funds for the Eleventh Five Year Plan

(Rs. Crore)

Sr. No.	Head	2007-2012	2007-08	2008-09	2009-2010	2010-2011	2011-2012
1.	**National Laboratories**						
	(i) Sectoral Requirement	8710	2450	2550	1700	1260	750
	(ii) Ongoing Commitments of Xth Plan	600	200	200	150	50	0
	(iii) Creating, nurturing & sustaining the core knowledge frontier	1000	200	200	200	200	200
	(iv) Scale-up and validation leads developed in-house	500	50	100	125	150	75
	(v)Opensource drug discovery programme for infectious disease	500	50	100	100	125	125
	(vi) Laboratory modernisation for eco-friendly sustainable growth	500	100	100	125	125	50
	(vii) Civil infrastructure rennovation, Staff Quarter & Amenities	1000	150	250	300	200	100
2.	**National S&T Human Resource Development**	1490	220	270	300	325	375
3.	**Intellectual Property & Technology Management**	230	30	60	60	40	40
4.	**R&D Management Support**	850	150	250	200	150	100
5.	**New Millennium Indian Technology Leadership Initiative**	1200	150	200	250	300	300
6.	**Setting up Institute of Translational Research**	1000	150	200	300	200	150
	TOTAL	**17580**	**3900**	**4480**	**3810**	**3125**	**2265**

Chart-II Proposed Distribution Under XI Plan

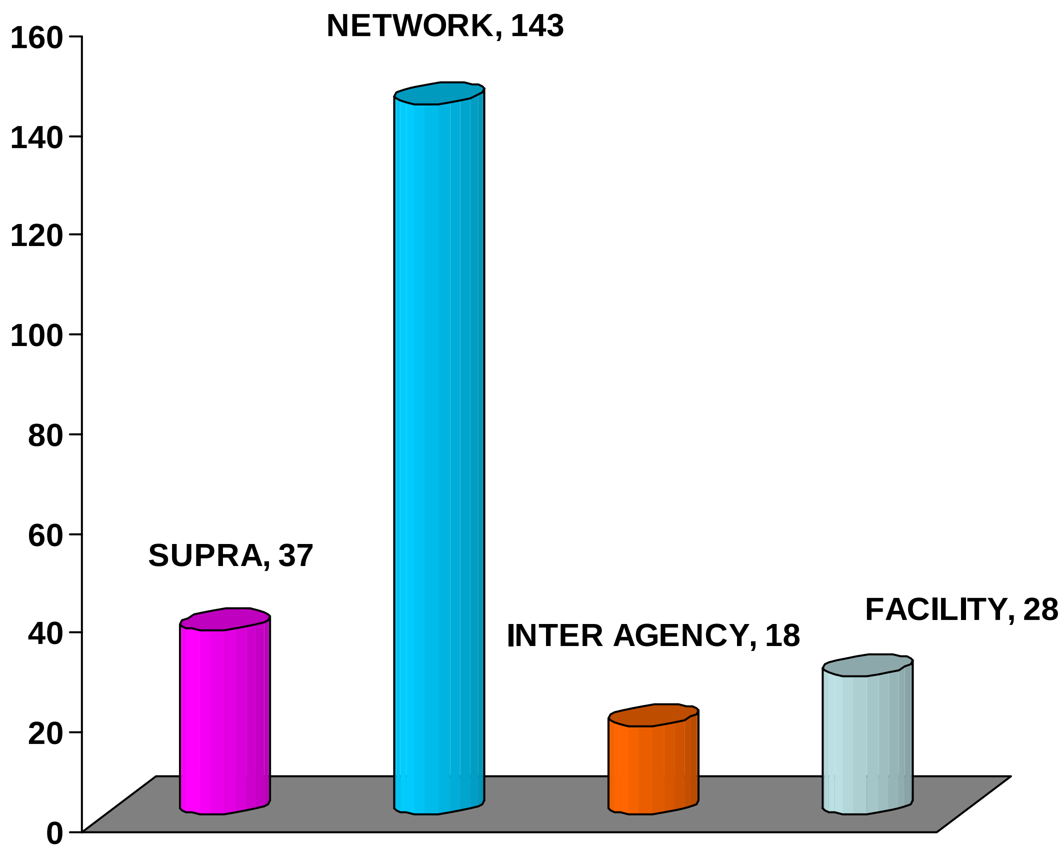


Figures in Rs.crore & corresponding % to total

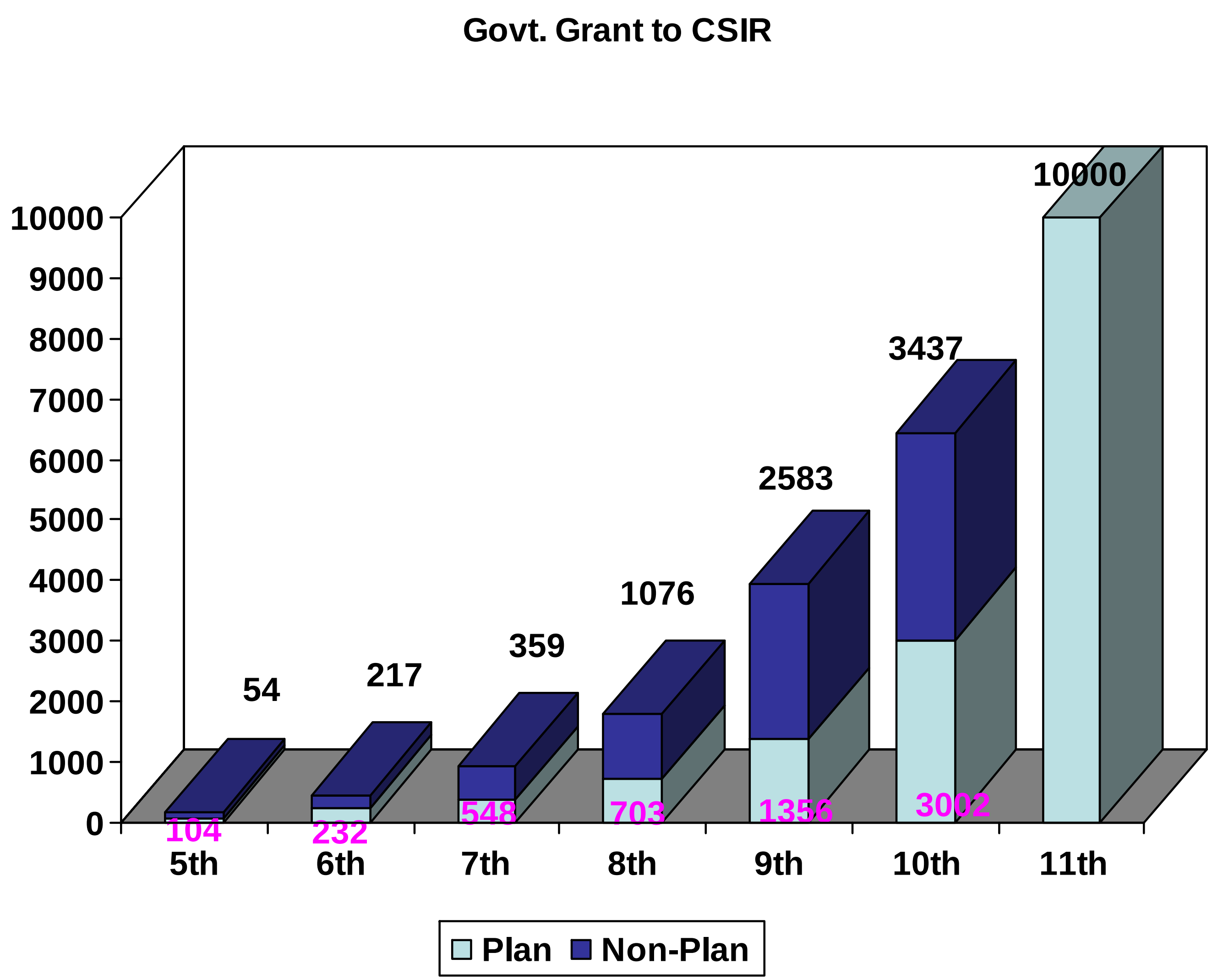
Table-V Sectoral Distribution of XI Plan Projects under National Laboratories

S.No.	Sector	Supra Institutional Projects	Network projects	Inter Agency Projects	Facility Creation	Total no. of Projects
1	Aerospace Science & Engineering	1	0	1	2	4
2	Agro, Food Processing& Nutrition	4	6	2	5	17
3	Biology & Biotechnology	7	12	2	4	25
4	Chemical Science & technology	2	6	0	1	9
5	Earth System science	4	6	4	1	15
6	Ecology & Environment	2	7	0	1	10
7	Energy Resources & Technology	3	5	4	2	14
8	Electronics & Instrumentation	2	5	0	0	7
9	Engineering Materials, Minerals & Manufacturing	4	12	0	2	18
10	Pharma, Healthcare & Drugs	4	10	2	4	20
11	Housing, Road & Construction	3	11	0	2	16
12	Information Technology	0	12	0	1	13
13	Leather	1	2	2	2	7
14	Metrology	0	1	0	0	1
15	Rural Development	0	41	0	1	42
16	Water Resources & Technology	0	7	1	0	8
Total		**37**	**143**	**18**	**28**	**226**

Chart- III Distribution of Projects in XI Plan



Figures are in numbers

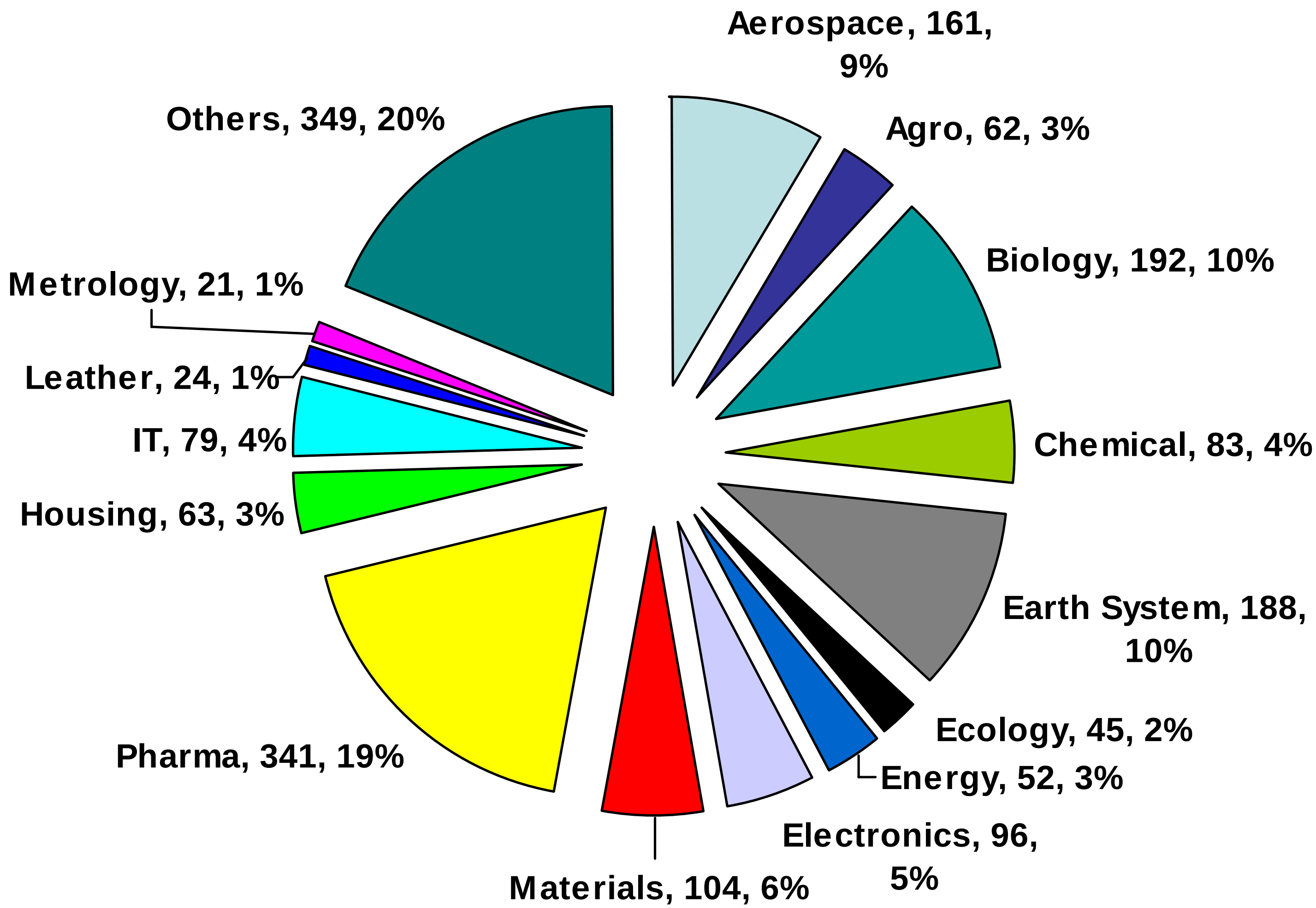


Figures are in Rs.crore

Table-VI Distribution of Approved Outlay in Xth Plan & Proposed Outlay for XIth Plan under National Laboratoires

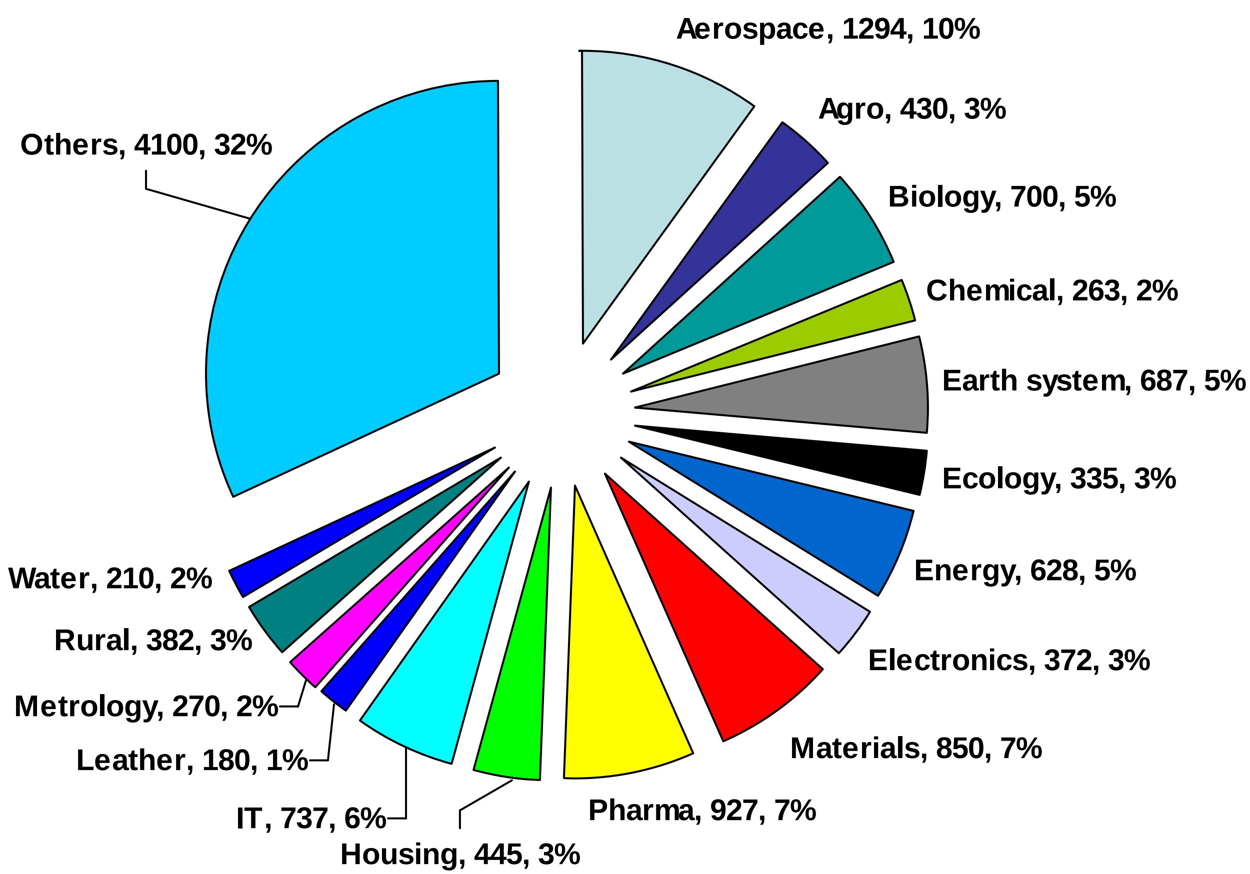
S.No.	Heads	Xth Plan		XIth Plan Proposed	
		Approved Allocation	% of total Allocations	Projected	% of total Allocations
	(i) Sectoral distribution				
1	Aerospace Science & Engineering	161	8.47	1294	10.10
2	Agro, Food Processing& Nutrition	62	3.26	430	3.36
3	Biology & Biotechnology	192	10.11	700	5.46
4	Chemical Science & technology	83	4.37	263	2.05
5	Earth System science	188	9.89	687	5.36
6	Ecology & Environment	45	2.37	335	2.62
7	Energy Resources & Technology	52	2.74	628	4.90
8	Electronics & Instrumentation	96	5.05	372	2.90
9	Engineering Materials, Minerals & Manufacturing	104	5.47	850	6.64
10	Pharma, Healthcare & Drugs	341	17.95	927	7.24
11	Housing, Road & Construction	63	3.32	445	3.47
12	Information Technology	79	4.16	737	5.75
13	Leather	24	1.26	180	1.41
14	Metrology	21	1.11	270	2.11
15	Rural Development	0	0.00	382	2.98
16	Water Resources & Technology	0	0.00	210	1.64
	Total	**1511**	**79.53**	**8710**	**67.99**
	Others				
	(ii) IX /X Plan commitments	39	2.05	600	4.68
	(iii) Creating,nurturing & sustaining the core knowledge frontier	250	13.16	1000	7.81
	house	0	0.00	500	3.90
	(v) Opensource drug discovery programme for infectious disease	0	0.00	500	3.90
	(vi) Laboratory modernisation for eco-friendly sustainable growth	0	0.00	500	3.90
	(vii) Civil Infrastructure & Refurbishment	100	5.26	1000	7.81
	Total	**389**	**20.47**	**4100**	**32.01**
	Grand Total	**1900**	**100.00**	**12810**	**100.00**

Chart- IV Allocations Under Xth Plan for National Laboratories



Figures in Rs.crore & corresponding %to total

Chart -V Sector wise distribution of proposed allocation under National Labs for XI Plan



Figures in Rs.crore & corresponding % to total

LIST OF PROGRAMMES FOR ELEVENTH FIVE YEAR PLAN

Supra Institutional Programmes

S. No.	Name of the Programme
	Aerospace Science & Engineering
1	Technology Development and R&D Initiatives in Aerospace (NAL)
	Agro, Food Processing Nutrition Technology Sector
1	Niche food processing technologies for outreach of cost effective, safe, hygienic, nutritious food , the targeted population (CFTRI)
2	High value products from agro forestry resources from the Himalayan region & improving productivity and quality of product development (IHBT)
3	Development of evidence based herbal products for preventive health and disease management (RRL-Triv.)
4	Biodiversity assessment prospection and conservation of plant resources (NBRI)
	Biology & Biotechnology
1	An Integrative Biology Approach in Deciphering Genotype - Phenotype Correlation for Human complex Disorders (IGIB)
2	Evaluation and Correction of Mitochondrial Dysfunction in Disease (IICB)
3	Investigative Toxicology: New Paradigms (ITRC)
4	Identification and characterisation of pollutants/products: environmental & human safety (ITRC)
5	Enhancing water utilization efficiency in crop plants: prospecting plant diversity for genes and systems biology for drought tolerance (NBRI)
6	Understanding the Molecular Mechanism of diseases of National Priority Developing Novel Approaches for effective management (IMTECH)
7	Therapeutic proteins, ultra stable enzymes and other proteins of importance: Science, Engineering & Technology Development (IMTECH)
	Chemical Science & Technology
1	Enabling Science for Building Specific R&D Capabilities (CSMCRI, Bhavnagar)
2	Competency building through creation of centres of excellence (NCL, Pune)
	Earth System Science
1	Evolution of the Indian Lithosphere - Focus on majo earth processes natural resources and the geo-environment since the break-up of Gondwana Super content (NGRI)
2	Science for development of a forecasting system for the waters around india (NIO)
3	Multi-scale simulation and quantification of sustainability and vulnerability under climate variability and climate stress and other natural hazards (CMMACS)
4	Seismic hazard-risk evaluation (RRL-Jorhat)
	Ecology & Environment
1	Competence building in the Molecular Environmental Science (NEERI)
2	Risk Assessment and Management of Environmental Pollutants (ITRC).

S. No.	Name of the Programme
	Energy: Resource & Technology
1	R&D on Photovoltaics and Other Solar Energy Applications(NPL, N. Delhi)
2	Energy for cleaner and greener environment (CECRI, Karaikudi)
3	To develop know-how and technology for environmental friendly conversion and utilization of biomass to fuels, lubricants and additives (IIP, Dehradun)
	Electronics, Photonics & Instrumentation
1	Technology development of Smart Systems (CEERI)
2	Technological Solutions for Societal applications (CSIO)
	Engineering Materials, Mining/Minerals & Manufacturing Technology
1	Development of speciality glasses for strategic and industrial application (CGCRI)
2	Ceramic materials for emerging technologies involving liquid and gas separation (CGCRI)
3	Capability development in manufacturing of Mobile Robotic system for national security, disaster management and Hazardous Applications (CMERI)
4	Development and forming of performance driven specal steels (NML)
	Pharmaceutical, Healthcare & Drugs
1	New drug development programme for parasitic diseases and microbialinfections (CDRI)
2	New drug development programme for reproductivehealth and life-style diseases(CDRI)
3	Development of novel target based anticancer therapeutics(RRL-Jmu)
4	Centre for Chemical Genomics (IICT)
	Housing, Road & Construction
1	Management tools for maintenance, Scheduling and life enhancement of special structures (SERC)
2	High Performance Materials and Construction Technologies for Sustainable Built Space (CBRI)
3	Development of a Management System for Maintenance Planning and Budgeting of High Speed Road Corridors under NHDP (CRRI)
	Leather
1	Atom economy and energy efficiency through thermodynamic insight for first principle led process innovations in leather and footwear and paradigm shifts in chemical to bio processing of leather (CLRI)

Network Programmes

S. No.	Name of the Programme
	Agro, Food Processing Nutrition Technology Sector
1	Design and development of equipment with automationand semi-automation for theproduction of ethnic/traditional foods in smallscale industry (CFTRI)
2	Innovations and emerging technologies in food processing (CFTRI)
3	Nutraceuticals and bioactive molecules from food and non food sources (CFTRI)
4	Development of transgenic crop plants for resistance toinsects pests (NBRI)
6	Isolation/Synthesis and evaluation of Nutraceuticalsof vegetable oil origin (IICT)
7	Development of supercritical fluid technology for extractionand separation of bioactivephytochemicals and drugdelivery (RRL-Triv.)
	Biology & Biotechnology
1	Gene -Environment Interaction (CCMB)
2	Cell and Tissue Engineering of Plants (CCMB)
3	Plasma Proteomics Health, Environment and Disease (CCMB)
4	Regulatory RNA in Development, health and disease (CCMB)
5	High Altitude biology with focus on Indian Cold deserts (RRL-Jammu)
6	Exploitatiom of India's rich microbial diversity (IMTECH)
7	Engineering peptides and proteins for new generation therapies (IICB)
8	Pathway engineering and system biology approach towards homologousand heterologous expression of high-value phytoceuticals (artemisinin, taxanes, picrosides, morphine,withanolides. (CIMAP)
9	Biological & Chemical Transformation of Plant Compounds for Production of Value Added Products of Therapeutic/Aroma Value. (CIMAP)
10	Bioprospection of viruses and phytoplasma and its down stream uses (IHBT)
11	Novel approaches for detection of incorporated genes in modified GM crops (ITRC)
12	Molecular approaches for detection and saffety :contaminants in potable water and food. (ITRC)
	Chemical Science & Technology
1	Development of New Adsorbents and Membranes for Potential Application in Separation Technologies (CSMCRI, Bhavnagar)
2	Development of Specialty Inorganic Materials for Diverse Applications (CSMCRI, Bhavnagar)
3	Agrochemicals and Intermediates (IICT, Hyderabad)
4	NCL-IGIB Center (NCL, Pune)
5	Polyner supported immobilized enzymes for chiral combinational bio catalysts and chiral resolution of racemic drug molecules (NCL)
6	Conducting polymer paints & coatings for corrosion protection & shielding of concrete structures in strategic areas (NCL)

Network Programmes

S. No.	Name of the Programme
10	**Earth System Science**
1	On-land and Off-shore Integrated Geophysical Studies to map the Lithospheric Structure along Kavali-Udipi Profile (NGRI)
2	Atmospheric carbon dioxide sequestration through fertilization of a high-nutrients-low chlorophyll (HNLC) oceanic regions with iron (NIO)
3	Tectonic and oceanic processes along the Indian Ridge system and back arc basins (NIO)
4	Multi-scale Modeling Platform (CMMACS)
5	Trace Gases, Aerosols, Radiation and Impact Assessment (NPL)
6	Uncertanity reduction, vulnerability impact assessment, mitigation policy intervention and capacity building for Global Change (NPL)
	Ecology & Environment
1	Resource conservation through recycle/ reuse of wastes with recourse to recovery of value added products. (NEERI)
2	Remediation/ Eco-restoration and cleanup of contaminated sites (NEERI)
3	Waste treatment and disposal (NEERI)
4	Climate change and adaptation of species complexes (IHBT)
5	Environmental contaminants: New screening technologies and effect on human health (ITRC)
6	Mapping of the Marine Biodiversity along the Indian Coast (CSMCRI)
7	Inhibition of quorum sensing and biofilm formation by marine algae and algae from high altitude: Potential for development ofenvironment friendly antifouling agent (CSMCRI)
	Energy : Resource & Technology
1	Bioenergy technology: Strategy designing of *Jatropha curcas for biodiesel (NBRI)*
2	Functional organic materials for Energy Efficient Devices (RRL-Triv.)
3	Developmetn of gas to liquid (GTL) Processess for DNE & Fischer-Tropsch fuels (NCL)
4	Hydrogen economy initiative (NCL, Pune)
5	Development of Coal to liquid (CTL) technology for synthesis of liquid from hydrocarbons (CFRI, Dhanbad)
	Electronics, Photonics & Instrumentation
1	MEMs and Mocrosensors for Requirements in Food, Health Environmental and social Sectors (CEERI)
2	Design and Fabrication Capabilities for Vey High Power, High Efficiency and Very High Frequency Microwave Tubes (CEERI)
3	Fabrication of LED Devices and Systems for Solid State Lighting Applications (NPL)
4	Photonics for Communication, Sensor and Laser Technology (CGCRI)
5	Instrumentation for applications in Agriculture, Food and public safety (CSIO)

Network Programmes

S. No.	Name of the Programme
	Engineering Materials, Mining/Minerals & Manufacturing Technology
1	Technology for Assessment and Refurbishment of Engineering Materials and Components (NML)
2	Development of Advanced Lightweight Metallic Materials for Engineering Applications (RRL-Bhopal)
3	Non oxide cermaic based advance structural materials: Armours and Refractories (CGCRI)
4	Development of Electronic Materials and devices (NPL)
5	Nano-structured Materials (NML)
6	Light Weight Metals and Alloys: Beneficiation, Extraction and Material Development for Structural use (NML)
7	Cutting Edge Technologies for Materials and Resources Conservation (NML)
8	Cpability Building of Advanced Manufacturing Processes of value added Components (CMERI)
9	Modular Re-configurable Micro Manufacturing Systems (MRMMS) for Multi Material Desktop Manufacturing Capabilities (CMERI)
10	Development of Advanced Eco-Friendly, Energy Efficient Processes for Utilization of Indigenous Mineral Resources (RRL-Bhub)
11	Development of improved process package and equipment for maximizing clean coal recovery and waste utilization (RRL-Bhub)
12	Development of suitable biomaterials and process techniques for preparation of patient specific implants for rehabilitation (CGCRI)
	Pharmaceutical, Healthcare & Drugs
1	Plants and Microbes as Bioreactors for the productionof Pharmaceutically andIndustrially Important Proteins (NBRI)
2	Diabetes Mellitus -New Drug discovery R&D, Molecular mechanisms andgenetic factors (CDRI)
3	Cell and Tissue Engineering of Animal and Human Cells (CCMB)
4	Development of comprehensive insilico tool forcost effective clinical trials (IGIB)
5	Development of diagnostics and target based molecular medicines against allergy bronchial asthma and chronic obstructive pulmonary disease (IICB)
6	Identification and validation of drug targets for selected pathogens (CDRI)
7	Validation of Identified Models and Development of new alternative models for evaluation of new drug entities (CDRI)
8	Nanomaterial and Nanodevices in Health and Disease (CCMB)
9	Comparative Genomics and Biology of non-coding RNA in the human genome IGIB)
10	Discovery and Preclinical studies of new bioactive molecules(natural and semi-synthetic)& Traditional Preparations(CSIR Hq.)
	Housing, Road & Construction
1	Track-bridge interaction studies in Indian Enviornment (SERC)
2	Enginering of Structures against natural & other disasters (SERC)
3	Computational Modeling & Simulation for High Performance materials (SERC)

Network Programmes

S. No.	Name of the Programme
4	Corrosion in Oil and Gas structural Facilities (CBRI)
5	Development of Value Added materials & Processes for Building Industry (CBRI)
6	Energy Efficient Structural Systems (CBRI)
7	Proactive Vulnerability Mitigation Methodologies (CBRI)
8	Research Pradigms using Accelerated Pavement Testing Facility (CRRI)
9	Development of traffic Management Centres & its application for Delhi Region (CRRI)
10	Performance Evaluation of Highway
11	Multi functional additives to cement for faster setting, -- & self cleanning surface properties (RRL-Triv.)
	Information Technology
1	Comprehensive Traditional Knowledge Digital Library (NISCAIR)
2	National Science Digital Library (NISCAIR)
3	Consortium Access to Electronic Journals for the benefit of CSIR labs (NISCAIR)
4	E-Access to Databases (NISCAIR)
5	Data Analysis, Management and Outreach (DAMO) platform (CMMACS)
6	Web Portal on Plant and Animal Diversity in India (NBRI)
7	Cheminformatics patinformatics (URDIP)
8	Scientific Knowledge Grid, High Power Computing, Data Centres (ITD)
9	e-Records System for CSIR and its Laboratories (ITD)
10	World Science Watch (NISCAIR)
11	R&D in Core Information Technology (NISCAIR)
12	National Repositories Portals & Open Access Journal Portal along with Citation Database (URDIP)
	Leather
1	Zero emission research initiative (CLRI)
2	Process & product innvoation (CLRI)
	Metrology
1	Advancement in Metrology
	Water: resource & Technology
1	Development of cost effective mine water reclamation technology for providing safe drinking water (CMRI, Dhanbad)
2	Sustainable Development and Management of water resources in different Problematic terrain(NGRI, Hyderabad)
3	Development of hollow fiber membrane technology for water disinfection/purification and waste water reclamation(CSMCRI, Bhavnagar)
4	Membrane technology for water purification and desalination (CSMCRI, Bhavnagar)
5	Development of Technology Package For High Capacity desalination (CSMCRI, Bhavnagar), Arsenic Removal Plants and Wastewater Treatment (CGRCI, Kolkatta)
6	Onsite technological intervention for remediation of water resources pollution (NEERI, Nagpur)

Network Programmes

S. No.	Name of the Programme
7	Treatment methodologies for water, wastewater (NEERI, Nagpur)

**** There are 41 Network projects under different areas for North East for the sector Rural Development***

Inter-Agency Programmes

S. No.	Name of the Programme
	Aerospace Science & Engineering
1	Designing and developing a regional aircraft specially suited for developing economies (Phase-1) (NAL)
	Agro, Food Processing Nutrition Technology Sector
1	Minimizing the food wastages through cost effectivebackward and forward linkages and by utilization of the by-products (CFTRI)
2	Technology intervention for quality products from cereals and legumes for convenience/traditional foods (CFTRI)
	Biology & Biotechnology
1	High Through -put and High contents Screening for Bioactive Molecules: Mining from folk-medicine Knowledge base (IGIB)
2	New Insights in cancer Biology : Identification of novel targets anddevelopment of target based molecularmedicine (IICB)
	Earth System Science
1	Integrated Geophysical studies along Daman - Jabalpur profile on Central India (NGRI)
2	Dynamics of separation of key Gondwanaland blocks: An integrated petrotectonic approach to decipher the early evolution of the western Indian Ocean (WOPET). (NIO)
3	Development of a High-Resolution Analysis (CMMACS)
4	Near-real time prediction of ionospheric & tropospheric corrections in radio signals (NPL)
	Energy : Resource & Technology
1	Development of a composite approach suitable for clean coal initiative (CMRI, Dhanbad)
2	Development of Multi-kW Planar SOFC System for Operation Below 800oC having Multi-fuel Capability (CGCRI, Kolkatta)
3	Development of Lithium-ion batteries for multifarious applications (CECRI, Karaikudi)
4	Development of Underground Coal Gasification and IGCC Technology in India (CMRI, Dhanbad)
	Pharmaceutical, Healthcare & Drugs
1	Pharmacogenomics and Predictive Therapy for Complex Diseases (IGIB)
2	Validation of Ayurvedic Concepts of Prakruti in metabolic disease Predisposition, progression and Drug response with special focus on metabolic disorders (IGIB)
	Leather
1	Collagen based materials for application as health care products (CLRI)
2	Rationalization of tools, techniques and methodologies for analysis and testing and support to minimization of occupational hazard (CLRI)
	Water
1	Utilization of indigenous know-how to address drinking water need in coastal/rural areas (BARC Mumbai & CSMCRI)

Facility Creation

S. No.	Name of the Programme
	Aerospace Science & Engineering
1	Up-gradation and Creation of Facility (NAL)
2	Advanced centre for High Mechanics & control (NAL)
	Agro, Food Processing Nutrition Technology Sector
1	Regional facility for nutraceuticals/ cosmetically/ value added products (IHBT)
2	Model food processing incubation centres by CFTRI and RRL-Jorhat
3	CSIR centre for human resource development in food science and technology (CFTRI)
4	Nodal codex food laboratory and referral centre for organic nutraceuticals & GM foods(CFTRI)
5	Centre for plant biotechnology (NBRI)
	Biology & Biotechnology
1	Facilities for Functional Genomic Research (IGIB) (i) Cellomics Facility (ii) Zebrafish Facility (iii) LC-NMR facility
2	Setting up a compact high energy light source radiation for the structural analysis of biomacromolecules (CCMB)
3	National Center for Genomics and Metabolomics (NBRI)
4	Advanced Center for Protein Informatics, Science, Engineering & Technology (IMTECH)
	Chemical Science & Technology
1	Center of Excellence for Lipid Research (IICT, Hyderabad)
	Earth Science & Technology
1	The Indian SHRIMP Facility (NGRI)
	Ecology & Environment
1	Sophisticated Environmental Analytical Instrumentation Facility (NEERI)
	Energy : Resource & Technology
1	Development of Fuel Cell Testing and Validation Facility (NCL, Pune)
2	Autonomous Centre for Battery Testing (ACBT) (CECRI, Karaikudi)
	Engineering Materials, Mining/Minerals & Manufacturing Technology
1	Centre of Excellence on Plasma Processing of Minerals and Materials (RRL-Bhub)
2	Advanced centre on mechanochemistry and reactivity of solids (NML)
	Pharmaceutical, Healthcare & Drugs
1	Establishment of Dog Facility for research and testing purposes (CDRI)
2	Functional MRI and MRS facility for investigation of molecular & cellular processes in rat and Human (CCMB)
3	High throughput fragment based screening using X-RAY/NMR on proteins from pathogenic sources and rational inhibitor optimization.

Facility Creation

S. No.	Name of the Programme
	Housing, Road & Construction
1	Establishment of National Facility for Remote Structural health monitoring (SERC)
2	Centre of Excellence for Advanced Structural (CBRI)
	Information: Technology, Resources & Products
1	State-of-the-art multi-teraflop High Performance Computing (HPC) facility (CMMACS)
	Leather
1	Design Centre for Leather Products (CLRI)
2	Material design and development centre (CLRI)
	Rural Development, weaker sections, women & North East
1	State-of-the-art analytical facility for North East (RRL-Jorhat)

VOLUME - II

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE
WORKING GROUP FOR ELEVENTH FIVE YEAR PLAN

OCTOBER 2006

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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE WORKING GROUP FOR ELEVENTH PLAN

1. Background to DSIR

DSIR is a one of the three departments of Ministry of Science and Technology, formed in 1985 with a view to promote industrial research, technology development, transfer and its utilization. The DSIR has two public sector undertakings viz. Central Electronics Limited (CEL) and National Research Development Corporation (NRDC) and two autonomous organizations viz. Council of Scientific and Industrial Research (CSIR) and Consultancy Development Centre (CDC). DSIR also provides the host facilities to Asian and Pacific Centre for Transfer of Technology (APCTT). This report will discuss the plan proposals of all the constituents of DSIR except the CSIR, which are discussed separately.

1.1 Unique Features of DSIR

DSIR holds a unique position in the government because of the following:

- Around 1200 in-house R&D units of Industry recognized by DSIR in five sectors viz. Chemicals, Electrical & Electronics, Mechanical, Process Industry and Agro & Food Processing Industry
- Around 550 Scientific and Industrial Research Organizations recognized by DSIR in Agricultural Sciences, Medical Sciences, Natural and Applied Sciences and Social Science
- National R&D Awards for significant R&D Achievements
- A well established mechanism for supporting multi-disciplinary projects for development of innovative process/product technology
- A well established mechanism to support individual innovators enabling them to convert their innovative ideas into working models/prototypes
- Data of around 400 companies with exportable technologies and projects which is expected to grow to 1000
- Database of approved foreign collaborations
- Centres of Technology and Innovation Management in academic institutions

- Subject specific information portals such as coastal hazards portal, science & technology portal, portal on Indian tea, textile technology research portal and database on traditional knowledge and folk wisdom

- NRDC, a PSU totally dedicated to commercialization of indigenous technology within the country and abroad. Also, specializes in patent assistance and training

- CEL, a PSU dedicated in research and manufacture of solar photo-voltaic systems, railway electronics and strategic electronics.

- CDC maintains a database of around 2500 technical consultants and consultancy organizations and has a membership of around 800 consultants

1.2 Limitations of DSIR

- A small department with a total strength of around 100 including just 40 technical officers

- A small budget outlay (10^{th} Plan approved outlay Rs. 145 crore) as a result of which most schemes operate at sub-critical levels.

- Space constraints (presently sharing a small percentage of space with DST in Technology Bhawan)

2. Working Group for Formulation of 11^{th} Plan Proposals

A working group was formulated under the chairmanship of Dr. R.A. Mashelkar, Secretary, DSIR vide DSIR Order No. DSIR/TPDU/XI Plan/07(1)/2006-07 dated 7^{th} July, 2006. A copy of the order is given at Annexure 1. The working group met twice on 31^{st} July, 2006 and 29^{th} August, 2006 and the minutes of these meetings are given at Annexure 2 and Annexure 3, respectively.

3. Performance in Tenth Plan

3.1 Department of Scientific and Industrial Research – TPDU Programmes

DSIR operated a scheme on “Technology Promotion Development and Utilization (TPDU) Programmes” in the tenth five year plan. The scheme was an outcome of consolidation, merger and dropping of some of the schemes operated in the ninth five year plan. TPDU Programmes endeavoured to: encourage industry to increase its share in country’s R&D expenditure; support a larger cross section of small and medium industrial units to develop start-of-the art globally competitive technologies of high commercial potential; catalyze faster commercialization of lab-scale R&D; encourage individual innovators to translate their ideas into workable prototypes; enhance the share of technology intensive exports in overall exports; strengthen industrial consultancy & technology management capabilities; and establish user friendly information network to facilitate scientific & industrial research in the country.

There were six components of TPDU scheme. Performance and major achievements of each component of the scheme during the tenth plan is briefly described below:

3.1.1 Industrial R&D Promotion Programme

- 5 National in-house R&D conferences held
- 38 R&D units bagged DSIR National R&D Awards for Outstanding in-house R&D achievements
- 410 new in – house R & D units recognised
- 1800 in – house R&D units granted renewal of recognition
- 120 new SIROs recognised
- 950 SIROs were granted renewal of recognition
- Around 3200 essentiality certificates for claiming customs duty exemption by DSIR recognised SIROs issued
- Around 450 essentiality certificates issued for claiming central excise duty exemptions
- 160 approvals u / s 35 (2AB) were issued (Form No.3CM)
- 200 certificates (Form No. 3CL) for weighted tax deduction u / s 35(2AB) were issued by DSIR to the Director General (I.T. Exemptions)
- 30 commercial R&D companies have been approved
- 560 registration / renewal of registration certificates issued to Public Funded Research Institutions / Universities

3.1.2 Technology Development and Innovation Programme

3.1.2.1 Technology Development and Demonstration Programme

Objectives:

(a) Development of need-based technologies that are oriented towards:

- human welfare,

- natural hazards mitigation,
- conservation of natural resources and sustainable development.

(b) Strengthening the interface between industry, R&D establishments and academic institutions.

Support for Technology Development projects**:**

Providing partial financial support for :

- Development and demonstration of technology for new and improved products and processes by industrial units in all sectors / areas

- Absorption and upgradation of imported technology

- Priority Technology development projects of PSUs in consultation with and co-financing from economic ministries

To Provide partial / full financial support for :

- Lab scale / bench scale technologies developed by national laboratories / institution, international research laboratories and universities and their scale up and commercialization by Indian industries

- Consortium projects for development of technologies of common interests for group of industries / associations to be undertaken by industrial units, National Laboratories, User Industries in important focused areas such as Electronics & Communications, Railways, Drugs, Chemicals & Fertilizers, etc.

- Development of technologies at national laboratories / Govt. supported research organizations / institutions for use by cluster of industries

- Technology missions in important areas such as healthcare, machine tools, capital goods, telecom products, environmentally sound technologies, socially relevant areas like visual aids, hearing aids, rural technology upgradation, natural products and other areas

- Patent filing in India and abroad

A number of number of projects have been supported by DSIR under the programme. Many of these projects have not only been successfully completed but commercialized also. Following achievements are given by way of examples:

i. **Interactive Small Arms Training Simulator (ZEN iSATS)** has been developed by M/s.Zen Technologies Ltd., Secunderabad. The firm has commercialised the technology and entered into co-production cum development agreement with Bharat Dynamics Limited (BDL), a Ministry of Defence Undertaking.

ii. **Composite Insulators for high power transmission** have been successfully developed by Goldstone Teleservices Ltd., Hyderabad and commercialized silicone polymer Insulators for 66 kV, 132 kV, and 400 kV power transmission lines using their own compound developed in-house.

iii. **Technology for Manufacture of Digested Organic Supplement (DOrS) and Enriched with Micronutrients** has been developed and commercialized by M/s. T. Stanes & Co. Ltd., Coimbatore. The product is non-toxic, environment-friendly and compatible with soil micro flora and other chemical fertilizers. It is a unique product, which contains beneficial microorganisms in an immobilized state. It is enriched with potassium as sulphate of potash, mixed with Neem fractions like Neem cake. It is available in pasteurized powder and pellet form for easy application and suitable for all types of soil.

iv. **Two types of water based inks viz. water based flexo inks used for absorbent stock (craft paper) and coated stock (art paper, etc.) and UV radiation curing inks used for coated stock and non-absorbent substrates such as PVC, Polyster, etc.** have been developed by M/s Organic Coatings Limited, Mumbai. The inks have been produced at commercial scale.

v. **Technology for manufacture of Tetrabromobispheonl-A (TBBA)** has been jointly developed by Solaris Chemtech Ltd., (Formerly BILT Chemicals Ltd.), Secunderabad and IICT, Hyderabad. The product Tetrabromobispheonl_A is a flame retardant which is having a good market in Asian and European countries. It is highly effective as a reactive flame retardant in epoxy resin systems due to its structural compatibility, high bromine content and thermal stability. The technology has been commercialized.

vi. **Process for hydrogen sulfide removal and recovery of sulphur from sour gases** has been jointly developed by Gujarat Narmada Valley Fertilizer Co. Ltd., Bharuch, Gujarat and Engineers India Ltd, New Delhi. This process is effective for low and fluctuating H2S gas. The H2S removal efficiency is nearly 100% and converts it into elemental sulphur. Iron or Vanadium complexes are used as catalyst and the process is very versatile. This technology was successfully demonstrated at ONGC, Hazira plant. The technology has been commercialized. Recently, some of the Bio-fuel manufacturers have approached NRDC for transfer of technology for removal of H2S. NRDC is actively considering transferring this technology to these manufacturers.

vii. **Liposomal Amphotericin B.** The process for manufacture of Liposomal Amphotericin B, which was initially developed at Delhi University and clinical trials carried out at KEM Hospital, Mumbai, has been scaled up by Lifecare Innovations Pvt. Ltd., New Delhi. The process is patented in India and the technology transferred to M/s. Lifecare Innovations Pvt. Ltd., through NRDC. This Liposomal drug developed in India is available at 1/10th cost of imported Liposomal Amphotericin B. It is life saving in patients with systemic fungal infection occurring in diabetes, mellitus, kidney transplant and cancer patients. It is also very effective in the treatment of kala-azar. The product was formally launched on ‘Technology Day’ i.e. 11th May 2003.

viii. **Process for manufacture of Pyrazinamide using Catalytic route** was jointly developed by SPIC Ltd., Chennai and IICT, Hyderabad. The process of making Pyrazinamide comprises of following three steps:

(a) Cyclisation of ethylenediamine with propylene glycol to 2-methylpyrazine
(b) Amoxidation of MP to 2-cyanopyrazine (CP)
(c) Hydrolysis of CP to Pyrazinamide

In the above given process steps (a) and (b) are catalytic reactions. The catalysts for each of these two steps have been developed separately by SPIC as well as IICT thereby resulting in the development of 4 catalysts. These catalysts have been found to be very efficient. The project has been successfully completed and the technology is available for transfer.

ix. **An Improved Tilting Disc Heart Valve Prosthesis** is being developed by TTK Healthcare Ltd., (TTKHL), Bangalore in association with Sree Chitra Tirunal Institute for Medical Sciences & Technology (SCTIMST), Trivandrum. This project is a continued R&D programme for developing a new model of TTK-Chitra Tilting Disc Heart Valve Prosthesis with following improved features:

MRI compatibility
Reduced production costs
Improved thrombo-resistance

At present, trials on sheep are in progress.

x. **Development of process for isolation of natural dyes from the forest plants of Uttranchal.** The process has been developed and demonstrated in a pilot plant at FRI, Dehradun (isolation of natural dye from one more plant material is in progress). The experience and capabilities acquired by FRI under the project are being extended to a similar project undertaken by Sikkim Khadi & Village Industries Board, Sikkim for isolation of natural dyes from the plant materials of Sikkim Region.

xi. **Cotton Seed Delinting Plant** has been successfully developed and commercialized by Maharastra Seeds Corporation Ltd. The plants are pollution free and so far 6 plants of various capacities have been sold. The company has got patent and design registered.

The special Features:

- Pollution free cotton seed delinting plant
- No use of sulphuric acid for hydrochloric gas generation
- Possible to delint small lots of even 10 kg.
- All machines coated with Teflon and lined with FRP for corrosion resistance.
- Minimum electric power consumption
- Economical price compared to imported and indigenous plants
- No hazardous operations
- Maximum use of gravity flow of seeds.
- Recommended by Commissioner Agriculture, Ministry of Agriculture, GOI

xii. **An integrated pilot demonstration plant for spice processing** has been jointly developed by Mata Foundation, New Delhi and RRL, Trivandrum. In another project Mata Foundation jointly with CFTRI, Mysore has established **integrated pilot demonstration plant for fruit processing**. The technology for Spice processing (Ginger) has been commercialized and the trial runs for fruit processing in the pilot plant are in progress.

The above examples show that the programme has met its objectives by developing new processes / technologies / products and strengthening the interface between industry and R&D establishments and academic institutions. The programme has played an important catalytic role in the innovation chain and cutting edge technologies have been developed in some cases.

Status**:**

Projects Completed	108
Ongoing	56
Foreclosed	26
Total	190

During the first four years in 10th Plan	35 new projects approved 5 projects completed.

Association of National Labs/ Institutes / Universities in executing TDD Projects	44 organisations involved in 81 projects

Royalty received from 35 projects / companies	Rs.6.16 crores
Royalty received during the first four years of X Plan	Rs.4.57 crores

IPRs associated with the projects supported under TDDP**:** 24

No. of Patents	20
No. of Trademarks	3
No. of Design registrations	1

3.1.2.2 <u>Technopreneur Promotion Programme</u>

TePP (Technopreneur Promotion Programme) jointly operated by DSIR (Department of Scientific and Industrial Research) and TIFAC (Technology Information, Forecasting and Assessment Council) of DST (Department of Science and Technology) is the jubilee year gift of Government of India to individual (independent) innovators. It is unique in several respects:

- The only program jointly operated by two departments in Ministry of Science & Technology. TePP secretariat is in DSIR and all activities - proposal screening, evaluation, project funding, monitoring are equally shared between DSIR and TIFAC.
- About 30 scientists of DSIR & TIFAC are involved in TePP and all of them carry out this task as additional responsibility. Multi tasking, multi pillar, hierarchy less structure makes TePP structure unique.
- The only program in GOI where government is directly funding individual innovators.
- Despite the small value of grant and large number of beneficiaries spread over the country, each project is independently monitored with visits to the innovator.

Aim was to support 100 individual innovators in the 10^{th} plan. Funding was available in two phases:

<u>Phase I</u>
Technopreneurship Support(TS) ... maximum support Rs 50,000/-
TePP Project Fund (TPF) …maximum support Rs 10 lakhs

<u>Phase II</u>
Supplementary TePP Fund (STF) … maximum support Rs 5 lakhs
Seamless scale-up support (S3T) …maximum support Rs 30 lakhs

STF is for technology transfer from innovator to industry and S3T is for innovator becoming entrepreneur based on his innovation.

Over 6000 ideas were accessed and 1240 applications were accepted for processing, of which 880 were screened in by the TePP group for evaluation by experts. These evaluated proposals were discussed in the TePP Screening Committee and finally 142 were recommended for support.

Illustrative examples

- In the 1950s, Professor Gavril Abramovich Ilizarov devised and developed his revolutionary method for treating fractures, deformities and other bone defects. Using a circular external fixator he was able to show that controlled, mechanically applied tension stress produced reliable and reproducible regeneration of bone and soft tissue. Prasad Narayan Kulkarni of Sangli was determined to bring this technology to Indian masses and with limited support under TePP developed *motorized Auto-distractor.* Clinical trails showed promising results of bone regeneration, a boon to correct birth defects of short or deformed legs.

- Innovative farmer Bhanji Bhai Mathukia of Junagadh developed a small 3 wheeled *10 HP tractor*. TePP supported him to develop an engineered product by networking with ARAI, Pune and CFMT&TI , Budni. The technology was licensed to M/S Pramal Farmatics (P) Ltd, Anand.

- Entrepreneur Ramesh Nibhoria developed environment friendly *solid biomass Furnace* , installed it at Jawahar Navodaya Vidyalaya, Nafajgarh and demonstrated the savings in fuel (LPG) consumption. More installations are underway in various schools.

- Teacher innovator Dr Jagadeesh of Kavaraiputtai developed an unique vertical cylindrical solar water heater with lotus flower shaped reflector.

- Retired DRDO scientist RA Yadav has taken up redesign of Surgical bandage cloth making machine.

- Loving mother Smt Pragnya Dilip Bhatt, determined to make her visually challenged son feel the shape of flowers, is perfecting a sketching device for use by visually challenged.

The 10th plan performance of TePP was reviewed on 15th July, 2006 at IIT, Bombay. Recommendations of the review committee were the following:

i) Processing time to be reduced to 4 months from receipt of application to either sanction or regret.
ii) Calibrated decentralization essential to take full advantage of TUC potential.
iii) The local expert evaluation to be honoured to a great degree and reasons to be cited if his views are overruled by another expert. This will create a sense of belonging to TePP.
iv) Clear policy needed for faculty innovations.
v) Activity flow chart and checklist to be prepared for TUCs.
vi) Regret letters should be dispatched as soon as decision is taken and reason for rejection to be explained so as not to hurt the feelings of creative person.
vii) TUCs need to be supported for advertisement, local travel and at least one full time person exclusively for promoting TePP to be employed on a contract basis.
viii) Model IP sharing contract may be prepared as guide for small institutes.
ix) There is need for utility patents in the country.
x) International fair on innovations to be organized to give global visibility to TePP innovators.

xi) Extensive training programs to be arranged on creativity to bring a new generation of young Indians strong in technology and creativity.

xii) Innovators need to be educated on making business plans, the pain points of user.

xiii) Grass root innovators to be perceived as ‘source’ rather than ‘sink’ for creative solutions.

xiv) Open source innovations with great diffusion potential to be encouraged.

xv) Innovations meeting needs of ‘Bottom of Pyramid’ can be transferred to other developing countries.

xvi) To make any noticeable impact, TePP should be scaled up and minimum 1000 innovations need to be supported in XIth plan. This would call for processing 10,000 applications and accessing above 50,000 ideas.

3.1.3 International Technology Transfer Programme

India’s merchandize exports had touched US$ 102 billion during 2005-06 and the target for the year 2006-07 is US$ 126 billion. According to World Trade Report 2006, India’s share in world merchandise exports inched up to 0.9 % in calendar year 2005, during which India recorded US$ 90 billion out of total global exports of US$ 10,121 billion. The technology intensive exports roughly constitute around 25% of the merchandize exports. While India contributes to 0.9% of world merchandize exports, in terms of high, medium and low technology exports, its contributions are merely 0.15 %, 0.3 % and 1.9 % respectively. Services exports stood at a level of around US$ 67 billion during 2005-06. The technology intensive exports have been growing at an average growth rate of around 25% over the last three years compared to the growth rate of around 20% of merchandize exports. The services exports have been growing even faster. Thus, it would be prudent to accelerate technology intensive and services exports. This would also help in speedy realization of the national export target of 1.5 % of world exports by the year 2009, as stated in the Foreign Trade Policy 2004.

The DSIR is the only department in the government of India which has a programme to promote export of technology. It has been operating an "International Technology Transfer Programme” which is aimed at promotion of international technology transfer and trade including export of technologies, projects, services and technology intensive products. The Programme nurtures India’s potential to export technology and hi-tech products. The Programme promotes technology exports for several reasons, one - technology exports establish a long term relationship with the overseas customer, two – technology exports have a multiplier effect on exports, three – technology exports enhance the export competitiveness in today’s age of rapid product obsolescence and lastly, technology exports create a brand image for the country.

The Programme Objectives

a. To compile information on exportable technologies and technology intensive projects, products & services available with Indian industry and R&D establishments

b. To create awareness about our technology export capabilities among potential foreign buyers or collaborators
c. Support capability building of industries and R&D establishments for technology intensive exports
d. Support research and analytical studies aimed at providing inputs to the government for technology export related policy formulation
e. Promoting and supporting Institutional Mechanisms to catalyze international technology transfer and trade
f. To facilitate signing of MoUs / Agreements on High Technology Cooperation and Trade between Indian and foreign industrial units

Major Achievements

(a) The programme supported carrying out surveys of small and medium enterprises (SMEs) in various states of the country to compile profiles of exportable technologies and projects available with them. Grouping of States and status of work completed/ underway is given below:

Proposed Regional Grouping of States	**Status**
Maharashtra	Project completed
Delhi & NCR	Project completed
Punjab, Haryana, HP & J&K	Project completed
Andhra Pradesh & Karnataka	Draft Report Available
Tamilnadu & Kerala	Draft Report Available
West Bengal & 8 NE States	Project in progress
Gujarat & Rajasthan	Project in progress
Uttar Pradesh, Uttaranchal, Bihar & Jharkhand	Project in progress
Madhya Pradesh, Chattisgarh & Orrisa	Project in progress

(b) The department has been setting up a Technology Trade Pavilion at India International Trade Fair, Pragati Maidan, New Delhi every year since 1997

(c) The programme has supported setting up of a “Technology Trade Facilitation Centre” at NRDC

(d) The programme supported organization of **“**International Training-cum-Awareness Programmes” in select technical areas aimed primarily at overseas participants.

(e) The programme has supported two institutional mechanisms:

Technology Export Development Organisation (TEDO) in association with Confederation of Indian Industry and Centre for International Trade in

Technology (CITT) in association with Indian Institute of Foreign Trade (IIFT).

(f) DSIR and Department of Commerce under its MAI scheme and Focus CIS Programme jointly took up a Project on Promoting High Technology Cooperation and Trade between India and CIS Countries.

3.1.4 **<u>Consultancy Promotion Programme</u>**

<u>Objectives</u>

The main objective of the programme is to strengthen and promote industrial consultancy services and capabilities for domestic use and export requirements. The various areas include the following: -

- Consultancy services within the country for the establishment of new enterprises, improving the performance of the existing units including sick units, mergers and acquisitions, etc.
- Infrastructure development
- Consultancy services for acquisition or import of technologies, requiring technological and managerial competence to evaluate the technologies and engineering them as per local requirements, Promoting quality Foreign Direct Investments (inward and outward).
- Consultancy services for export of projects, technologies and services and setting up Joint Ventures abroad, etc.
- Consultancy services for development and transfer of technologies from R&D institutes and strengthening linkages of R&D system with industry.
- Consultancies for new and emerging areas of national interest.
- Other areas as may be identified including special efforts for consultancies for SMEs and tiny sector.

Activities/achievements during 10^{th} Plan include:

- The Food Processing Technologies and Services Centre (FPTSC) at Kanpur has been set up by UPICO-CFTRI with the support of DSIR and the Pilot plant facilities at CFTRI Centre, Lucknow and Analytical Laboratory Facilities at Kanpur were established.

- Consultancy Clinic at Katni (MP) mainly for Lime Kiln Industry was completed.

- The project for Setting up of a Consultancy Clinic for IT sector by CDAC, NOIDA was supported.

- The project for Creation and Maintenance of Industry Specific Sectoral National Online Database of Consultants and Consultancy Organizations in India by CDC has been initiated.

- The study for Development of Model Grading/Rating System for Consultants in India in association with ICRA Ltd was initiated.

- The project for Setting up of Consultancy Clinic for Hosiery Industry at Kanpur by U.P. Industrial Consultants Ltd. was initiated

- The project for Setting up of Consultancy Clinic for Jute & Jute Diversified Products by West Bengal Consultancy Organisation Ltd., Kolkata was initiated.

- The project for Design & Engineering Centre for Mould Designs used in Automotive and Durable Consumer Goods with Class A Surfaces by PSG College of Technology, Coimbatore was initiated.

3.1.5 <u>Technology Management Programme</u>

<u>Objectives and Activities under the programme</u>

i. Studies on technology and innovation management areas (including case studies)
ii. Collaborative work with Industry / Research / Academic / Consultancy/ Government bodies and others
iii. Industry-institute networking through creation of region-specific resource centers.
iv. Information dissemination on TM issues through Newsletters, Manuals, Paper contests on specific technology related issues.
v. Training/Interaction meets/ Seminars/ Management Development Programmes including specific programmes for trainers as well as lectures by Distinguished Technologists.
vi. Technology Audit parameters (commenced on pilot basis in 10^{th} Plan)
vii. Compilation and analysis of foreign collaborations (NRFC as per Allocation of business for DSIR)
viii. Curriculum development in TM (commenced in 10^{th} Plan)

<u>Highlights of the Programme during 10^{th} Plan</u>

- Technology gaps and trends in respect of 180 products/ processes have been identified and measures suggested for further development.
- More than 40 case studies and other teaching aids prepared in emerging areas of TM, are being put for pedagogic use.
- Intense projects spanning several activities have been undertaken in association with 5 geographically distributed institutions across the country.

- More than 150 training programmes on emerging areas of technology transfer, knowledge, R&D and innovation management including IPR have been organized.
- More than 8000 persons have been trained in the above programmes.
- Around 20 need identification studies have been carried out including the rural sector and North East region; covering Medicinal & Aromatic plants, Minor Forest Produce, Vegetable dyes, cashew etc.
- 4 Centres have been launched to facilitate industry-institute interaction in different locations.
- Newsletters catering to topical TM needs are being brought out by 5 different organizations.
- 3 research studies on TM benefiting industry and academia have been completed.
- 3 portals on Technology management have been launched

3.1.6 Technology Information Facilitation Programme

The programme formulated during the Tenth plan had the following objectives:

- Develop appropriate endogenous information capacities to support R&D activities
- Support the production of local content and to promote indigenous knowledge
- Promote information and knowledge networking at local, regional and national levels to facilitate flow and sharing of information resources
- Map the national S&T productivity in relation to the international S&T Productivity
- Support education, training and R&D in digital content development and utilization
- Promote national and international cooperation in related areas

Major Achievements

Databases and Content Development

- Creation and maintenance of a bibliographical and digital image database of available literature and material on Bishnupur terracotta art and sculpture and Traditional design of Potchitra, Baluchori & Madhubani *(Kolkata)*
- Computerized botanical database on wild ornamental plants of Himalaya (*Nauni, Solan*)
- Multimedia Software Database of available pest management technologies of major oilseeds and pulse crops of central India (*Jabalpur*)
- Floral potential of J&K State: Survey and Documentation (Srinagar)
- Preparation of Database on Metallopharmaceuticals

National Websites / Portal

- Portal on Indian Tea and strengthening of electronic networking system (Valparai, Coimbatore)
- Science & Technology Portal *(Pune)*
- Development of the Coastal Hazards portal *(Goa)*
- Indigenously developed textile technology research *(Ahemedabad)*
- Industrial R&D in India: A Web Portal (Hyderabad)
- Online Directory of Indian Academic & Research Establishments (Bangalore)

Documentation of traditional knowledge and Folk wisdom

- Scouting for grass-root level innovations, compilation and dissemination of information in local languages across India (SRISTI, Ahmedabad)

- Documentation of community knowledge, traditional knowledge, and oral traditions" in eight districts of the state of Karnataka with special reference to agriculture and rural practices *(Manipal)*

- Isolation & Documentation of Indigenous Knowledge & Conservation of Traditional Practices in Theni, Virudhunagar, Sivagangai, Dindigul and Madurai Districts in Tamilnadu (*Anand Nagar Krishnankoil, Virudhnagar Dist)*

- Folk Wisdom of West Bengal *(Kolkata)*

- Documentation and preservation of Agricultural Traditional Knowledge by Modern Electronic Media through Farmer Participatory Approach (Madurai)

- Design and development of database on folk knowledge (Aurangabad)

- Studies on Tradition Folk Herbal Veterinary Medicines and Poisonous plants of Rajasthan (Udaipur)

- Development of a Portal and Kiosk of Goldsmith's skill towards enhancement of entrepreneurship abilities among unemployed youth *(Durgapur)*

Virtual Information Center (VIC)

- VIC Resources for Wider Access to Reliable & Affordable STM information *(Hyderabad)* (*http://www.vic-ikp.info*)

Electronic publishing of selected Indian S&T materials

Open Archive Initiatives (OAI)

- Establishing MOLTABLE- An Open Access initiative for Molecular Informatics (Pune)
- Development of OAI-based Institutional Research Repository Services in India (Bangalore)

Surveys and R&D Studies

Education and Training

- Web based interactive multimedia training programme on Digitization and Digital libraries (IGNOU)
- Training programme on Content Development and management (Mumbai)
- Digital Content Development for Human Resources Development of Rubber Industry (IRMA, Mumbai)
- Model (Software and procedure) for web-driven distance education system (Delhi)

Expert Meet / Brain storming Sessions/Seminars

- Four brain-storming sessions at Pune, Bhubaneswar, Chandigrah and Hyderabad were held. Experts from industries and R&D institutions participated in the meeting.
- National Conference on Community Information Service : Challenges and opportunities for library (Varanasi)

3.1.7 Technology Development and Utilization Programme for Women (TPDUW)

Objectives

The objectives of the programme are:

- Promoting the adoption of new technologies by women
- Awareness creation and training of women in various technologies
- Technological Upgradation of tiny, small and medium enterprises run by women entrepreneurs
- Showcasing of appropriate technologies and organizing demonstration programmes for the benefit of women

Performance since its Introduction

- Farm and Non-Farm sector employment and Tribal Women – a Socio-Economic Analysis
- Training of women in Computer Aided Drafting Package and Microsoft office software

- Empowering Women through Entrepreneurship Development in Amravati, Akola and Buldhana Districts, Maharashtra State
- Study on Impact of the Information & Communication Technology on Women Employment in Kerala
- Upgrading indigenous technology for preparation of herbal products as home remedies and food supplements by encouraging sustainable cultivation, conservation and propagation of medicinal plants involving rural women of West Bengal
- Training-cum-Workshop on Development of Modern Educational Training Kits for Women consultancy Cells
- Propagation of Technologies & Development of Micro Enterprises by Women in Andhra Pradesh, Orissa & Kerala States
- Identification of Gaps in Technology Utilization and Training for the Development of Rural Women (A Study in Andhra Pradesh
- Diffusion of Farm Technologies to Farm Women through User-Friendly Interactive Multimedia Compact Disc.

3.1.8 DSIR Financial Performance during 10th Plan (2002-2007)

(Rs. Crore)

S.No.	Programme	Outlay	Actual(Expected)*
1.	Industrial R&D Promotion Programme	2.50	1.0
2.	Technology Development & Demonstration TePP	44.0 5.0	37.0 3.0
3.	Int'l Technology Transfer Programme APCTT	7.5 7.2	6.0 6.0
4.	Consultancy Promotion Programme	11.0	8.0
5.	Technology Management Programme	5.0	3.0
6.	Technology Information Facilitation Programme	13.8	4.5
7.	IT Activities and Miscellaneous	3.0	1.5
	TPDU	**99.0**	**70.0**
8.	CEL	25	25
9.	NRDC	20	18
	Total	**144**	**113**

* BE figures for the year 2006-07 have been taken to work out the expected expenditure during the tenth plan

Reason for low expenditure: Approval of the scheme came only in March 2004

3.2 Central Electronics Limited

3.2.1 S&T Scheme

Physical

a. Upscaling of Solar Photovoltaic operations to 10 MWp per annum from level of 2.0 MWp, per annum, for becoming price competitive, through economies of scale, for tapping both domestic as well as huge export marketing opportunities in global markets to attain turn around of SPV operations.

b. Expanded SPV Export marketing operations by giving due thrust to utilize full enhanced capacity of SPV plant.

c. Developed and standardized process for using thinner wafers for bulk Solar cell production as a cost saving solution improving price competitiveness in both highly price sensitive domestic as well as export markets and also to overcome problems faced relating to availability and high prices of thicker wafers earlier used in the production.

d. Developed Building Integrated Photovoltaic Module (BIPV) considering its enormous commercial potential for roof top (as a building material) and economic at medium size SPV power plant applications in near future in domestic and also export markets

e. Developed high wattage (220 Wpk) modules proving to be economical for large SPV Power Plant in domestic market and having good demand in as export markets.

f. Expanded production capacity of Microwave Ferrites used for PCM production to cater for large projected requirement of PCMs for Weapon Locating Radars (WLR), planned for production in the country with DRDO technology.

g. Developed linkages with SSPL and other DRDO Labs, working on future technologies for Phased Array Radars, keeping in view long term business plan in this area.

h. Developed new components in Electronic Ceramics by acquiring new high grade PZT materials technology for components to be used for future technologies in Sonar area, and also for high volume applications like cellular/ mobile phones for dielectric ceramic products and Heat Fuse 551 for sustainable operations of Electronic Ceramics Division.

3.2.2 I&M Scheme

Physical

a. Upgradation and upscaling of Solar Photovoltaic operations from 2MW to 10 MW.

b. Regular production of larger size modules upto 220 Wpk capacity.

c. Induction of single entry digital axle counter and increased the capacity to produce around 2000 Axle counter per year.

d. Regular production and supply of phase control modules(PCM) and IFF system to DRDO.

e. Standardization of various PZT powder composition and supply of PZT components for hydro phones for Naval applications.

Financial

(Rs.in Crores)

	2002-03 (Actuals)	2003-04 (Actuals)	2004-05 (Actuals)	2005-06 (Prov.)	2006-07 (Expected)
Production	68.10	65.24	85.42	102.17	116.00

3.3 National Research Development Corporation

Commercial Activities

A. Gross Premia/Royalty And Other Income/Profit

(Rs. in lakhs)

Year	2002-03 (Actual)	2003-04 (Actual)	2004-05 (Actual)	2005-06 (Prov.)	2006-2007 (Projected)
Premia	138.58	115.58	93.25	136.35	150.00
Royalty	170.31	224.36	232.99	230.00	250.00
Export of Technology	8.75	10.10	3.28	--	20.00
Other Income	112.90	89.89	83.75	78.65	50.00
Total Income	430.54	439.93	413.27	445.00	470.00
Expenditure	417.90	420.58	400.67	430.00	447.00
Profit before tax	(+)12.62	(+)19.35	(+)12.60	(+)15.00	(+)23.00

B. Creditability with Industry

The credibility of NRDC with industry has increased during the 10th plan further as various industries operating in different sectors of economy approach the Corporation to license technologies so that they can face global competition. Corporation has been able to license 172 technologies and in their capacity in generating employment potential. Some of the licensed technologies have been in the field of national importance like drinking water (treatment and testing), medicines (777 oil for treatment of psoriasis), conversion of waste (Bio-conversion of Coir waste to Organic Manure), building materials (Manhole cover), herbal products (herbal beer, lipstick), energy saving (Nutan Himveer Bukhari, Kerosene wick lamp), Vaccines, etc.

- Number of technologies licensed during the years are :

Year	2002-03	2003-04	2004-05	2005-06	2006-07 (Expected)
Nos.	29	25	39	44	35

Social Impact

During 10th Plan national wealth of about Rs.300 crores in terms of goods generated/produced have been created by licensees of NRDC. Revenue generated for the Research Institutes is about Rs. 12.00 Crores from their technologies.

C. Networking with R & D Institutions

About 40 Memorandum of Understanding (MoUs) were Signed/ are likely to be signed with R&D institutions / universities / individual inventors during 10th Plan

D. Technology Networking

Year	2002-03	2003-04	2004-05	2005-06	2006-07 (Proposed)
Nos.	71	45	42	30	25

E. Knowledge into Wealth

In order to convert knowledge into wealth, the corporation has established in collaboration with Dialog of USA and set up 'on line patent search facility' which has been made or available to individual inventors, scientists and business managers. Through this facility the technology generator can access and benefits on a regular basis extensive collection of world wide information sources of more than 450 (databases) which covers information, on millions of documents and various scientific and technical literature. This facility enables them to convert knowledge into wealth more speedily.

F. Knowledge Alliances and Networking

Recently a virosome based targeted gene drug delivery system which has the potential to become platform technology was developed by University of Delhi and transferred to NRDC. This is based on F-virosome of Sendai virus and is highly liver cell specific. This plate form technology has a strong potential to develop a number of therapies and vaccines for several Diseases (Hepatitis, liver cancer, Hemopohilia, Malaria) which are originating from liver cell. NRDC has licensed the know how to M/s Panacea Biotech, New Delhi for manufacturing and marketing the product in India.

As NRDC is interested in marketing this delivery system as platform technology globally to international pharma companies, it has established a knowledge alliance with a laboratory located in Albert Einstein College of Medicine, New York and University of Delhi to conduct more in-vivo test and generate further needed data for evaluation of its efficacy on several diseased animal models. The knowledge alliance and networking thus worked by NRDC, will help it in licensing and commercialising the know how to various pharma industries abroad.

G. Initiative to Add Value to IP from other forms of Know-How/ Knowledge Base

Over the years NRDC has experienced that various researchers mainly working in the university system and some of the R & D institutions are able to develop knowledge base/know-how like an improved process on the basis of alteration/modification/additions/alteration of existing products and processes and which has definite commercial potential but has a shorter life period due to fast changing spectrum of technology.

In absence of utility model available for protection in India it is not advisable to go for prolonged patent protection procedure and even the researcher in university systems are allergic to long patent prosecution as they are quite familiar with immediate recognition through publications. Coupling of IP with such type of knowledge base/ know how has acted as a deterrent to the knowledge worker thus resulting in economic loss to both NRDC as well as to researchers who are not able to transfer their outputs. In order to overwrite this problem

NRDC has taken a new initiative to link this knowledge base from the various forms of IP protection procedures and transferring it straight way to the interested parties so that it can be utilised by the customer.

Promotional Activities

The Corporation is operating the following two programmes to promote development and transfer of indigenous technologies:

(i) Invention Promotion Programme (IPP)

(ii) Technology Promotion Programme (TPP)

- *Development and Promotion of Rural Technology*
- *Promotion of Export of Technology*
- Informatics for Technology Transfer
- *Technology Development Programme for Priority Projects*

These two programmes are run by NRDC with the support of Department of Scientific and Industrial Research (DSIR) which comes in the form of grants-in-aid.

4. Eleventh Plan Proposals

On the one hand, it is proposed to continue the 10th Plan scheme on TPDU Programmes with renewed thrust and on the other, some new initiatives have been also proposed in the 11th Plan. The proposed financial outlay for the 11th Plan in respect of schemes and programmes of DSIR, CEL, NRDC and CDC is given in Appendix 2 to Annexure 3. Scheme-wise details follow:

4.1 DSIR-TPDU Programmes

4.1.1 Industrial R&D Promotion Programme

The main objective of the programme is to strengthen application oriented research and development by nurturing the growth of R&D in industry and strengthening R&D infrastructure in industry. Proposed activities in 11th plan and the outlays are given below:

		Rs. in lakhs
*	National Awards for R&D Efforts in Industry	40
*	National Conference on in-house R&D in Industry/Workshops/get-togethers	40
*	Publication of Outstanding R&D Achievements, Directories, R&D Overview, R&D in Industry Updates and other related publications	30
*	Preparation of Status reports relating to IPR, in-house R&D systems	50
*	Support to Research Associations, SIROs	70
*	Misc. including office equipment, TA/DA, etc.	20
	Total	**250**

4.1.2 Technology Development and Innovation Programme

4.1.2.1 Technology Development and Demonstration Programme

Objectives:

(a) Development of need-based technologies that are oriented towards:

- human welfare,
- natural hazards mitigation,
- conservation of natural resources and sustainable development.

(b) Strengthening the interface between industry, R&D establishments and academic institutions.

Support for Technology Development projects**:**

Providing partial financial support for:

- Development and demonstration of technology for new and improved products and processes by industrial units in all sectors / areas
- Absorption and up-gradation of imported technology
- Priority Technology development projects of PSUs in consultation with and co-financing from economic ministries

To Provide partial / full financial support for :

- Lab scale / bench scale technologies developed by national laboratories / institution, international research laboratories and universities and their scale up and commercialization by Indian industries
- Consortium projects for development of technologies of common interests for group of industries / associations to be undertaken by industrial units, National Laboratories, User Industries in important focused areas such as Electronics & Communications, Railways, Drugs, Chemicals & Fertilizers, etc.
- Development of technologies at national laboratories / Govt. supported research organizations / institutions for use by cluster of industries
- Technology missions in important areas such as healthcare, machine tools, capital goods, telecom products, environmentally sound technologies, socially relevant areas like visual aids, hearing aids, rural technology up-gradation, natural products and other areas

- Patent filing in India and abroad

It is proposed that the scheme continues in the 11th Plan.

In view of the suggestions received during the first working group meeting, the following is proposed:

- to reduce the interest rate on repayable amount to 1%;
- to increase DSIR support up to 80% of project cost depending upon technological capabilities of beneficiary industry;
- to give priority for scaling up of globally patented know-how by Indian industry;
- to consider scaling up of lab scale know-how in areas such as nano, bio, new energy, new materials, waste utilization etc.;
- to link up with schemes such as TDB and support scale up of pre-commercialization phase of projects, as identified by experts;
- to play an active role in commercialization of spin-off technologies from atomic energy, defense and space sectors.

It is proposed to support around 60 new technology development projects aimed at developing state-of-the art globally competitive technologies of high commercial potential.

<u>Proposed budget outlay is as under</u>:

Rs. in Crores

2007-08	**2008-09**	**2009-10**	**2110-11**	**2011-12**	**Total**
11.50	11.50	12.00	12.00	13.00	60.00

4.1.2.2 <u>Technopreneur Promotion Programme</u>

Objective:	To build sustainable eco-system supportive of individual innovators
Aim:	To reach the tipping point by accessing 10,000 news ideas and supporting 1000 innovations in 5 years.
Structure:	Network with 20 out reach centers and others in the innovation promotion space.
System:	Decentralise gradually by releasing funds annually to public funded TUCs and NIF. Increase outer limit of support under Phase-I & II by 50%.
Activities:	Continuation of 10th plan activities and taking up new activities to give a push to “Creativity”.

Budget:

Funds for 1000 innovations	:	Rs. 40 crores
Limited support to TUCs (20nos)	:	Rs. 10 crores
Promotion, advt, publicity etc (international innovation fairs and others)	:	Rs. 10 crores
DSIR Share	:	Rs 30 crores
TIFAC (DST) Share	:	Rs 30 crores

Justification

i. Public funds are provided as grants to individuals not to subsidize their product development costs but to create an environment supportive of creativity and to build a large base of innovations to support innovative India. The numbers are critical in this game, the attempt is to scale up the activity to reach the *Tipping Point.* The "*tipping point*" is reached when the critical mass is obtained. The phrase "tipping point" is a sociological term that refers to that dramatic moment when something unique becomes common The concept has been applied to any process in which beyond a certain point, the rate at which the process (chemical, sociological, etc.) proceeds increases dramatically. Conditions necessary for tipping are:

- enrolment of network partners who have large connectivity with innovators/ entrepreneurs,
- supporting network partners to improve impact of their service
- and focusing on communication.

ii. In an eco-system the network partners have a growth charter of their own, TePP outreach centers (TUCs) need to evolve into creativity zones taking up the following activities:

- Handholding innovators at all stages of idea transit, from concept to market.
- Diffusion of technologies developed under TePP and from other sources to Rural Business Hubs.
- Mentoring innovators with business models, market entry strategies etc.
- Arranging funds from banks, VCs
- Helping in patenting
- Organizing exhibitions
- Running TePP training schools

Against tenth plan target of supporting 100 innovations, the 11^{th} plan aims to support on the average 200 innovations per year. This scale up is feasible with involvement of 20 TUCs.

The plan program envisages annual grant of Rs 10 lakh to each of the 20 TUCs.

- iii. The one factor that could hinder the transition of India to a developed country is limited CREATIVITY, the fertile ground for mushrooming of original ideas. This large issue is addressed by several organizations like CSIR, DST,CII, HRD and there can be no surfeit of initiatives at this stage. Original ideas are the feed stock for TePP and TePP has a large stake in augmenting supply of its inputs. TePP piloted few programs in creativity training and creativity competitions and plans to pursue them with greater vigour in 11th plan. It is proposed to strengthen exixting institutions such as NIF and establish chairs at several institutes to carry out research and training in creativity. A framework for a creativity institute could be also debated.

4.1.3 <u>International Technology Transfer Programme</u>

The proposed activities and outlays for the 11th five year plan are the following:

a) Research and Documentation	*Rs. 2 crore*
• Research into emerging technology issues and producing reports	Rs. 50 lakh
• Technology Exports Newsletters and Monographs on Technology Export Success Stories	Rs. 75 lakh
• Database of exportable technologies and projects	Rs. 75 lakh
b) Publicity and Promotion	*Rs. 12 crore*
• Participation in National and International Exhibitions	Rs. 5 crore
• Technology Trade Facilitation Centres	Rs. 3 crore
• Support to Indian Industrial delegations abroad	Rs. 1 crore
• Participation in Buyer-Seller Meets	Rs. 1 crore
• International Awareness Programmes in India and Abroad	Rs. 2 crore
c) Capability Building of Industries and R&D Establishments for enhancing their Technology Intensive Exports	*Rs. 3 crore*

It is proposed to organize programs for industry in areas such as IPR, product design, quality, export certification etc. for enhancing the competitiveness of their technology intensive products. Also, it is proposed to train and support SMEs to enable them to launch global operations.

d) Support to institutional mechanisms	*Rs. 10 crore*

Institutional mechanisms like Technology Export Development Organization (TEDO) with CII and Centre for International Trade in Technology (CITT) shall continue to be supported. Other institutional mechanisms with sectoral industry associations and other related agencies are also planned.

<u>New Activity</u>

It is planned to operationalize an Indo-Australian Bi-national Industrial Research and Development (BIRD) Programme. DSIR would participate in the collaborative projects between Indian and Australian industries for which Australia is prepared to commit some 2 million Australian Dollars. While the details of the programme shall be worked out, a provision of *Rs. 3 crore* as DSIR's matching grant is being made.

Total 11th Plan Outlay for ITTP ***Rs. 30 crore***

Asian and Pacific Centre for Transfer of Technology (UN - APCTT)

<u>Objective</u>

The objective is to extend GOI support to the Asia Pacific Centre for Transfer of Technology of the UNESCAP with a view to promoting international cooperation in the areas of industrial R&D, innovations and technology development and transfer.

<u>Activity-wise Breakup of Outlay for 11th Plan</u>

	(**Rs. crore**)
- Institutional support	7.50
- Programme support	5.00
- Support towards expenditure of capital nature	1.50
Total	**14.00**

4.1.4 <u>Consultancy Promotion Programme</u>

The following activities of the Tenth Plan will be continued in Eleventh Plan:

a) Consultancy Clinics
b) Design & Engineering Centres
c) Studies, seminars, conferences, training programmes etc relating to technological advances, consultancy capabilities and needs in India and abroad
d) Support to Consultancy Promotion Agencies and Associations
e) Support to Technical Consultancy Development Programme for Asia and Pacific (TCDPAP)

<u>Renewed Thrust in Eleventh Plan</u>

a) Recognition/bench marking of consultants

CDC in association with ICRA Ltd. is working on developing a model for accreditation/grading of consultants and consultancy agencies in India, which will be ready soon. Necessary modalities will be worked out for implementing the model. This mechanism would be of great help to clients in identifying the right type of consultants for their assignments as well as the consultants in enhancing the business opportunities. Also, it would enhance the image of Indian consultants and consultancy agencies, especially when a large number of foreign consultants are operating in India and giving a tough competition to Indian consultants.

b) Promotion of Education and Research Programmes in the area of consultancy in Universities and Institutions of Higher Learning

Presently the only academic degree programme in the area of consultancy is the MS Degree Programme conducted by CDC in collaboration with BITS, Pilani. This part-time programme is for working professionals and is restricted to persons in and around Delhi. With vast potential for consultancy in the present economic environment, It will be useful to start degree and post graduate programmes in universities and institutions of higher learning in the area of consultancy with practical orientation and focus on development of consulting skills and capabilities, employment generation which would in-turn generate work and wealth for the country.

c) Scheme for providing start-up support for new entrants in consulting in potential areas

There are no opportunities available for young professionals who are brilliant and have necessary expertise to start consultancy. Due to lack of support measures, most of them though have good ideas and the required capabilities, either take up employment or go abroad to pursue higher studies. Similarly, many retired scientists and other experts can be developed as good consultants through a proper support mechanism. Considering this, it is proposed to start a scheme to provide start-up support for those who wish to enter the consulting profession. Financial support through soft loan/grant can be provided for the initial 2-3 years based on the merit of the proposal and after evaluation and recommendations of the Technical Advisory Committee.

d) Federation of Technical Consultancy Organizations (TCOs)

There are 17 TCOs in the country providing consultancy services in various sectors of industry and the economy. Financial institutions like IDBI, IFCI, ICICI, banks and State governments set up these TCOs. During the last one and half decade it has been observed that while a few of these TCOs are doing very well, majority of them are not doing well even though the potential for consultancy services is quite high in almost all the States of the country. Due to such a situation, the successful TCOs have started operating in more than one region including those where the less successful ones are located. Considering the vast consulting opportunities emerging in various states due to the infrastrutural and other developments taking place, the TCOs need to be supported and interlinked through establishing a Federation for their effective working. Since DSIR is the nodal department in the country for promoting Indian consultancy services, it would be highly useful for DSIR to establish and coordinate the federation as a structured organization.

e) Scheme to support the interface of new entrant consultants with experts in the respective areas

Often, it is observed that most new entrants though have sound technical knowledge and competence, are not very successful in consulting business due to lack of practical experience. It would therefore be useful to associate experts in the relevant area to guide the new entrants to develop towards a successful consulting career. CDC, through DSIR support is in the process of developing a national database of consultants and domain experts. Support provided to new entrants as indicated above will be supplemented through support of relevant experts in the area identified from the database referred above or proposed by the new entrant to have an effective interface.

f) Technology Incubators & Consultancy Parks

Technology Incubators are developed as a mechanism to develop small businesses / start-ups businesses through a shared facilities for technology development and innovations. The models vary depending upon the objectives. This mechanism has been reported to be successful in USA, Germany, China, Korea, Malaysia, Japan and Singapore etc. One of the special features of this concept is that an individual inventor/entrepreneur by using incubator facilities may be able to convert his innovations into reality. It is therefore proposed to develop technology incubators around 4 select R&D labs. DST is engaged in promoting Technology Business Incubators and STEPs, which are mostly around academic institutions and are primarily aimed at promoting technology based businesses rather than technologies. However, these efforts need to be complimented through other agencies. DSIR is uniquely placed in favour of technology incubators since it has a chain of laboratories in CSIR and closer contacts with in-house R&D in industries, Research Associations, etc., and also is the administrative Department for various tax and fiscal incentives to R&D. Similarly, Consultancy Parks on experimental basis, are proposed to be promoted, to enhance consultancy business opportunities for individual consultants/professionals as well as to enhance export of construction projects, turnkey projects and services.

g) Promotion of consultancy need & capabilities in areas such as IPR, Bio-technology, New Materials, Infrastructure, Venture Capital Financing etc.

h) Linkages and tie-ups with foreign consultants

i) Support to consultants for bidding and executing in multi-lateral and UN funded projects

Rs. in Crore

Activity	Physical Target	Outlay
Clinics & Design Engineering Centres	Clinics – 20 nos. DE – 5 Nos.	15.00
Support to other Consultancy Agencies	-	2.00
Studies, Seminars, etc.	10	2.00
Registration of Consultants	-	5.00
International linkages & Networking with foreign consultants	20	2.00
Technology Incubators/Consultancy Parks	1	3.00
Miscellaneous including TA/DA, office equipment, etc.		1.00
Total Eleventh Plan		**30.00**

4.1.5 Technology Management Programme

The proposed activities in the 11th Plan are:

- *Technology Benchmarking and Audit*

  The Parliamentary Standing Committee has recommended that DSIR may undertake technology audit of public sector enterprises. The Division has gained experience in developing technology audit parameters and other related issues.

  It is proposed that we may undertake technology audit of 20 PSEs over the 11th Plan period.

- *Chairs in Technology and Innovation Management*

  With a view to give further thrust to research and teaching in technology and innovation management, it is proposed that 10 Chairs on the subject may be supported in different institutes covering IITs, NITs, IIMs, Universities and other specialized Institutes.

- *Technology strategy analysis*

  Industry, the research/academic institutions and the technology community need to be continually updated with information on future likely developments in their respective areas of work. Continuous tracking and trend analysis of global technological developments is imperative to remain competitive. It is essential to define and assess future business scenarios and accordingly strategize an innovation path in a dynamic mode. The Division is contributing towards this through region/product/process specific studies and analytical reports, enriched with visions and trends of technology leaders and business innovators. But to evolve a complete strategy, work in this area is proposed to be stepped up using other different mechanisms.

One mechanism that could be exploited is the patent document search. Even though a majority of patents granted may seem to be economically non-significant, a patent document is an important source of technical information. The patent document can reveal a lot of important information: current or future focus areas, mix of competitors and particular business roles, strong patenting activity can indicate growing research interest, number of patents granted to a single organization can indicate particular level of activity, abandoned patents can indicate the status of R&D efforts taken up to a certain extent. All in all, the analysis can be a very useful tool for management of technology portfolios, R&D management and for developing a technology strategy. It is proposed that efforts of the Division may be steered towards these and other such efforts.

- *Support to a Technology Management National Resource Centre*

  The Division has initiated the setting up of regional centres for Technology and Innovation Management in different locations of the country. These provide access to information on TM aspects of specific interest to the region of concern, expertise to advise and provide guidance on issues concerned with technology management, and generate long-term as well as short-term solutions. The activities taken up have been wide ranging: training, research, scouting innovation, manpower development, interfacing between academia and industries, data generation, sharing of knowledge and providing solutions to industries, cluster development studies, case preparation, technology related policy studies, developing training tools and modules. Five centres are currently operational and three more are on the anvil. It is proposed to create a national centre that would link the various sub centres and act as a forum for sustenance of aspects pertaining to technology management across these centres through networking and sharing of programmes and activities.

- *Technology-link cells in Institutes*

  It is proposed that the Division may prioritize sectors in a phased manner and link the R&D needs of these sectors with suitable cells located in select academic/research institutions to address developmental needs on an on going basis. The Division could assist in the setting up of these cells. A mechanism for profitable functioning of these cells on a continuing basis would be formulated by the Division.

- *Industry-institute fellowship/exchange programme*

  A mechanism for exchange/loan of scholars between industry and academia would be set up by the Division. Around 50 fellowships are proposed initially.

- *Register of International research alliances*

  Currently, there is no mechanism in place for tracking of international organizations that have established research bases in the country. It is proposed that we may create a Register of International Research Alliances.

- *Networking with International organizations*

  Technology management is being accorded a lot of importance by both developed and developing countries. Learning on these issues can be considerably enhanced by forging relationships with other countries. The Division may institute mechanisms for forging strategic alliances with reputed international institutions and agencies on these issues.

- *Innovation Policy Formulation*

  The Division may formulate a National Innovation Policy that would link with innovation oriented programmes of different agencies/other Government Departments and generate an integrated holistic policy.

Budget Requirement For 11th Plan

Ongoing work	Rs 10 crore
Technology Benchmarking and Audit	Rs 10 crore (20 organizations @ Rs 0.50 crore)
Chairs in Technology & Innovation Management	Rs 7.0 crore
Technology Strategy Analysis	Rs 2 crore
Technology Management National Resource Centre	Rs 10 crore
Technology-link cells in Institutes	Rs 5 crore
Industry-institute fellowship/exchange programme	Rs 2 crore
Register of International research alliances	Rs 0.50 crore
Networking with International organizations	Rs 3 crore
Innovation Policy Formulation	Rs 0.50 crore
TOTAL	Rs 50.0 crore

4.1.6 Technology Information Facilitation Programme

The programme is proposed to be fine tuned and priorities refixed during Eleventh Plan. It is also proposed to seek private sector involvement in its implementation, wherever feasible.

The critical areas of focus during Eleventh Plan under the programmes would be on content development and delivery of nationally available science and technology information and improving the technical competency of persons involved in information handling and delivery.

Content Development

Two major components of content development include the Research outputs of scientific institutions in India and Traditional Knowledge and Folk wisdom.

Research outputs of scientific institutions in India
A host of scientific institutions including Universities and research centres do publish several dissertations/ theses covering all branches of science & technology. The creation of centralized facilities in different regions for the collection and digitization of such outputs and its dissemination through electronic media would be given focus. In addition the reports generated out of research and development efforts funded by the Government and its agencies would also be collected and centralized dissemination through the regional facilities would be strengthened.

Traditional Knowledge and Folk wisdom.
India's diverse communities and its age-old traditions and heritage make it a country where indigenous knowledge abounds. Information, practices, beliefs, tools, materials and biological resources, which have been based on experience and have been tried and tested over centuries of use, have been passed down through generations in several ways. Oral traditions, folk media, stories and apprenticeships have ensured that the knowledge is alive, updated and used. Indigenous knowledge could be of the following categories:

- Locally bound, indigenous to a specific area
- Culture – and context- specific
- Non-formal knowledge
- Orally transmitted, and generally not documented
- Dynamic and adaptive
- Holistic in nature
- Closely related to survival and subsistence groups of persons or specific communities

The recognition that indigenous knowledge has a significant role to play in the development process and contribute towards sustainable development has raised the interest of grass root level workers, scholars, governments and international agencies. Several social trends and changes are leading towards a loss of indigenous knowledge. Since indigenous knowledge is often transmitted by word of mouth rather in written form, it is vulnerable to rapid change – especially when people are displaced or killed, etc. Some indigenous knowledge is lost naturally as techniques and tools are modified or fall out of use. The WTO regime has highlighted the need to record this indigenous knowledge, so that the community that "owns" this knowledge does not lose out to others who may claim it as their own and reap its benefit. It is imperative for traditional societies to explicate and record this knowledge, organize and collate it and disseminates it widely, thus staking their claim over it.

Indigenous Knowledge pervades all domain knowledge – agriculture, forestry, soil conservation, water management, food and nutrition, health and hygiene, pregnancy and child care, health and medicine, arts and crafts, etc. In many of these areas, women are key links in the indigenous knowledge preservation, dissemination and use chain.

In view of the above, it is proposed to give the requisite emphasis and focus in the documentation and digitization of traditional knowledge and folk wisdom and its delivery in regional languages. It would, however, require the establishment of a suitable mechanism and policies for ensuring the delivery of the traditional knowledge without compromising the rights of the persons/ community possessing such knowledge.

Information Delivery Systems

It is also important that effective and efficient delivery systems are developed for ensuring that S&T information available both nationally and internationally become available to the user clientele scattered through out the country. The specific activities proposed to be undertaken in this regard include the following:

Information Support to Industrial Clusters

The benefits of R&D activities and technology transfer programmes of DSIR are presently accruing to largely to a limited number of institutions which are generally in the organized sector. It is therefore important to initiate positive measures to broad base its activities so that the fruits of industrial research become available to a large cross-section of the industries.

The Small and Medium Enterprises (SMEs) in China could achieve substantial growth and export performance through technology up-gradation with the help of scientific institutions of that country. There is no reason why India cannot adopt such mechanisms. It is therefore proposed to set up a National Research Council – Industrial Research Assistance Program as a key enabler within the country's innovation system. This can provide SMEs with value added technological and business advices, financial assistance and a range of other innovation assistance. The activities involved in this would include the following:

- Enlist major clusters of production units in specific industry groups

- Document the technologies available including those developed by the CSIR labs suitable for each type of industry and production line.
- Prepare detailed project reports for the technology upgradadtion of the cluster including the steps involved and training requirements with the help of technology Advisers
- Provide assistance and technical inputs at every stage of technology Upgradation of the cluster
- Provide financial assistance and fiscal incentives for cluster wise technology Upgradation

Clearing house for S&T related information.

Since MNCs are setting up R&D centers in India, it is proposed to establish a clearing house facility in India for attracting R&D investments in the country. The facility is proposed to be set up as a joint venture project in collaboration with the private sector. It will network between various R&D organizations and provide information on current S&T activities and opportunities available for commercialization.

National Sectoral Portals

Information and Communication Technologies (ICT) are now internalized to the socio-economic fabric of the country. These all pervasive technologies can be fruitfully applied to all sectors of the economy, and the community of the scientific and industrial workers could be one of the beneficiaries. Information delivery through internet could be therefore profitably employed by setting up national sectoral portals in collaboration with scientific institutions in the relevant sectors.

Virtual Information System

Virtual information System has already been established in ICICIKP, Hyderabad which is acting as interface between institutions and industries for sharing S&T information. It is proposed to replicate atleast 2 more such facilities in other parts of the country during Eleventh Plan.

Electronic Publishing of Indian S&T materials

Though electronic publishing of Indian S&T journals has been taken up an activity during Tenth Plan to enhance the visibility and readership of such journals, only one such project namely Journals of INSA could be completed. It is proposed to intensify this activity during Eleventh Plan.

Open Archive Initiatives

This is also an activity taken up during Tenth Plan which would be continued during this plan period. Digital archives of intellectual products created by the faculty, research staff and students of specific institutions would be created and made accessible to end users both within and outside the country.

Competency Development

The development of information systems and its delivery to the targeted users cannot be achieved unless the necessary skill and competency development is given priority. The activities proposed to be undertaken in this regard during this plan period include the following:

Incubation Centres for Promoting Content Development

It is proposed to establish incubation centers in some of the selected universities to promote content development as a profession. Typically, the incubation centers will have the requisite computer and software facilities for imparting training in content development, experienced trainers and facilities for preparation of project profiles and feasibility reports. The centers will also have services of domain experts and language experts. The training component will include the following:

- ✓ Communication skills
- ✓ Domain knowledge
- ✓ Information organization skills
- ✓ Technology know-how
- ✓ Language capability and
- ✓ Improving creative talent

Formal & Informal Training Programmes

These training programmes would be targeted to information users and information managers and intended to enhance the skills and competence of knowledge workers. Both formal and informal programmes with the assistance of professional institutions would be taken up on identified areas like Intellectual Property Rights, Knowledge Management, Institutional Repositories, and Greenstone Software for Digitization, DSpace, etc.

Survey and Research Studies

Periodical surveys and studies would be undertaken to identify the user needs and to assess the new technologies and tools for information management. In addition sector specific studies on the impact of IT and Media convergence will be undertaken to evaluate the sectoral implications of the ICT and explore the new opportunities.

International Coordination

It is necessary to maintain meaningful liaison with international agencies involved in S&T information so as to adopt the international standards and tools & techniques. In particular the coordination with UNESCO, ESCAP, etc will be continued and technology familiarization visits will be made.

Activity	No & Rate	Amount (Lakhs)
4.1 Content Development		
Research outputs of scientific institutions in India	4 x 25	100
Traditional Knowledge and Folk wisdom.	10 x 20	200
4.2 Information Delivery Systems		
Information Support to Industrial Clusters	5 x 50	250
Clearing house for S&T related information	----	1300
National Sectoral Portals	10 x 20	200
Virtual Information System	2 x 75	150
Electronic Publishing of Indian S&T materials	5 x 13	65
Open Archive Initiatives	4 x 25	100
4.3 Competency Development		
Incubation Centres for Promoting Content Development	10 x 25	250
Formal & Informal Training Programmes	25 x 5	125
4.4 Survey and Research Studies	15 x 10	150
4.5 International Coordination		10
4.6 TOTAL		2900

4.1.7 Technology Development and Utilization Programme for Women (TPDUW)

Objectives

- Promoting the adoption of new technologies by women
- Awareness creation and training of women in various technologies
- Technological Upgradation of tiny, small and medium enterprises run by women entrepreneurs
- Showcasing of appropriate technologies and organizing demonstration programmes for the benefit of women

Projects Eligible for Funding

DSIR under its “Technology Development and Utilization Programme for Women (TDUPW)” provides assistance for those projects which are relevant to the betterment of women. In particular, the projects of the following nature are eligible for assistance:

- ➢ Studies/ surveys for the assessment of information needs of women in different walks of life.
- ➢ Documentation and content development on the following aspects:
  - Women's rights and legal provisions
  - Technologies useful for subsistence production, personal care and community management including food processing, water conservation, waste disposal, maintenance of health and hygiene, etc.
  - Best practices in promoting economic activities by women.
  - Contribution of women innovators/entrepreneurs.
  - Contribution of women Scientists/ Technologists working in various scientific laboratories.
  - Technologies and products beneficial to women.
  - Awareness creation and training of women in information and computer technologies.
  - Case studies of successful R&D and business women.

Outlay for 11th Plan : Rs. 6.5 crore

5. New Initiatives in 11th Plan

5.1 Small Business Innovation Research Initiative (SBIRI)

Introduction

Opening up of the Indian Economy with increased liberalisation and integration with the global economy has necessitated Indian Industry to take steps to reorient itself. Further, in the light of the Agreement on Trade Related Intellectual Property Rights (TRIPS) of the World Trade Organisation (WTO), the Indian Entrepreneurs have started thinking more and more about indigenous technologies, their development, perfection and absorption. However, the Indian industry has to speed-up its efforts to gain competitive advantage as a nation to capture the global market and generate wealth. The commercialization of new technologies and high tech projects in various industries needs to be accelerated to meet the future challenges and realise full potential of industries are at the forefront of another technological revolution and are definitely going to prove as the industry of the new millennium. Industrial research has vast potential for commercialisation in the areas of computers, information processing, electronics, drugs, pharmaceuticals (other than biotechnology based), chemicals, telecommunications, automobile & automobile components, aircraft, helicopters, materials, energy, environmental protection and others, and various industrial products emanating out of them. The global technologies have been undergoing dynamic changes in terms of perspective and priorities. Innovation is needed for development of new products and processes. There is a need to create a critical mass of small business units that have the potential to drive the innovation.

About the Scheme

The Small Business Innovation Research Initiative (SBIRI) would be the new scheme launched by the department to boost public-private-partnership effort in the country. The distinctive feature of SBIRI is that it supports the high-risk pre-proof-of-concept research and late stage development in small and medium companies lead by innovators with science backgrounds which is unique in nature to support private industries and to get them involved in development of such products and processes which have high societal and commercial relevance. SBIRI has unique process for generating ideas by bringing users and producers of technology together, it has the direct focus on producing product and a sense of urgency for producing defined results that only private sector engagement can produce. National consultations will be held after every three to six months to generate ideas in different sectors of technological development.

The SBIRI (other than Biotechnology) aims to:

- strengthen those existing private industrial units whose product development is based on in-house innovative R&D,
- encourage other smaller businesses to increase their R&D capabilities and capacity,
- create opportunities for starting new technology-based or knowledge-based businesses by science entrepreneurs,
- stimulate technological innovation,
- use private industries as a source of innovation and thereby fulfil government objectives in fostering R&D, and
- increase private sector commercialisation derived from Government funded R&D.

Objectives

The key objectives are:

a. to provide support for early stage, pre-proof-of-concept research in areas other than biotechnology by industry,
b. to support late stage development and commercialisation of new indigenous technologies particularly those related to societal and commercial needs,

c. to nurture and mentor innovative and emerging technologies/entrepreneurs, to assist new enterprises to forge appropriate linkages with academia and government.

Area Coverage

The scheme covers all areas related to computers, information processing, electronics, drugs, pharmaceuticals (other than biotechnology based), chemicals, telecommunications, automobile & automobile components, aircraft, helicopters, materials, energy, environmental protection and others, and various industrial products emanating out of them.

Who can apply?

The proposals can be made

- Solely by in-house R&D unit(s) of industrial firms; or
- Jointly by Industry and National R&D Organizations and Institutions: or
- Collaborative projects of common interest to the concerned sector/area proposed by a group of industries/users, national research organizations etc.

If the project involves collaboration among two or more partners, the scope of work and responsibilities of each participating establishment in the project should be highlighted. Public-Private Partnership is encouraged and all things being equal, this model will be preferred.

Eligibility criteria for Industry Partner

- The unit should be registered in India and must fulfill the criteria of Small Business Unit. Here a ‘Small Business Unit’ is defined as an enterprise with not more than 500 employees.
- The Company should have well established in-house R&D unit recognized by Department of Scientific and Industrial Research (DSIR) or have patent rights (National or International) in the proposed activity.
- Joint ventures and limited partnerships would be eligible for SBIRI support, provided the entity created meets the above requirements.

In case of projects focused on strategic and critical national needs, the eligibility criteria for a company can be relaxed at the discretion of the Apex Committee of SBIRI.

Funding structure

The SBIRI scheme will operate in two phases viz. for establishment of pre-proof of concepts of innovations and for product and process development. In both the phases, projects will be implemented at the industry site. However, in any case the actual project cost would not involve cost of land and building but only capital investment and recurring costs.

SBIRI Phase – I : The following structure of funding will be available to industry depending on the project cost and own resources brought in by the promoter to the project.

a. If the actual project cost is upto Rs. 25 lakhs, 80% of the project cost will be available as a government grant.

b. If the actual project cost is between Rs. 25 lakhs and Rs. 100 lakhs, 50% of the project cost will be available as government grant subject to a minimum of Rs. 20 lakhs and maximum of Rs. 50 lakhs.

c. If the project cost is beyond Rs. 100 lakhs, in addition to the Govt. grant of Rs. 50 lakhs, the unit will be eligible for interest free loan upto 50% of the amount (subject to a limit of Rs. 50 lakhs as loan) by which the total project cost exceeds Rs. 100 lakhs.

SBIRI Phase – II : It is proposed to provide soft loan upto Rs. 10 crores for a project as per its requirement. Soft loan upto Rs. 100 lakhs will carry a simple interest of 1% while the interest rate will be 2% (simple interest) on the amount of loan beyond Rs. 100 lakhs. The role of public R&D institution at this stage too is critical, as many of the projects would continue to require technical support from the public funded R&D institutions. The partner in the public institution at this stage will get the R&D support as grant.

Management

The scheme is coordinated by the Special Purpose Vehicle (SPV) under the guidance and directions of Department of Scientific & Industrial Research, Ministry of Science & Technology, Government of India through Apex Committee of SBIRI (ACS).

Monitoring

Each and every project supported under the scheme SBIRI will be monitored by the Internal Monitoring Committee (IMC) to be chaired by emeritus scientist/technocrat in that particular area designated by ACS and having the project investigators from all participating institutions and companies as members of this Committee. The Committee can have 3-4 external experts depending on the requirement. IMC will submit half yearly progress report to ACS for review.

Outlay for 11th Plan: **Rs. 500 crore**

5.2 Fund for Accelerating Start-ups in Technology (FAST)

Nitin Desai Committee on Technology Innovation and Venture Capital

Recommendation: Establish early stage venture fund through public-private partnership, under auspices of DSIR. Initial corpus to come from existing schemes supplemented by public & institutional resources.

Objective of FAST – Scheme

The first phase of FAST would provide seed capital to start-ups in the ICT sector seeking to create innovative products and services preferably based on Intellectual Property (IP) that find immediate application as solutions to customers' problems. Small business enterprises already in operation and employing not more than 500 persons are also eligible to apply. The scheme will operate in public private partnership mode.

Only projects where venture capital institutions issue a non-binding Expression of Interest (EOI) to support the start-up once the proof of concept is established using funds from FAST, would be eligible for support.

What Sectors Should FAST First Focus On?

India has achieved tremendous success in global markets in the IT, Life Sciences, and Auto Components sectors. FAST can therefore focus on these sectors and other high growth sectors that may emerge.

To begin with, it is suggested that FAST supports start-ups in the ICT sector. This is because the following conditions favour the emergence of a high-tech segment consisting of start-up firms developing cutting-edge innovations for global markets in this sector:

- Success and reputation of the existing software and services industry
- Availability of a large pool of high-quality, low-cost ICT graduates
- Presence of reputed software firms that could directly or indirectly contribute to the emergence of such a segment
- Web of personal and professional linkages with both Indians working in Silicon Valley and high-tech firms in that region and elsewhere in the US

- Key strategic investments in Indian innovation by high-tech firms such as Intel, Microsoft, and Cisco that could encourage creation of ventures around their offerings

The study of the Indian software industry by Avnimelech and Teubal (2003) also concludes that India is well poised to enter into an R&D intensive, Silicon Valley phase of its ICT industry. This phase would involve further expansion of the existing ICT industry and entry into higher value-added areas through the creation of large number of start-ups.

Creating an Ecosystem to Support High Technology Start-ups

DSIR, The Indian School of Business (ISB), Hyderabad, TiE propose to create an enabling ecosystem by bringing several partners together on a common platform. This ecosystem would provide:

- Mentoring and start-up management advice
- Access to technology skills to support product development
- Access to follow-up financing
- Intellectual Property (IP) Management
- Access to managerial talent with strong operating experience
- Access to product management and international business development support

DSIR & ISB would partner with the Indian Institute of Science (IISc) and The Indus Entrepreneurs (TiE), Hyderabad chapter to create this ecosystem.

<u>About ISB</u>

ISB has rapidly emerged as one of the leading institutions imparting management education in India. The School evolved from a need for a globally top-ranked and distinctive business school in the Asian region dedicated to providing the best management education. The School is the dream of some of the best minds from the corporate and academic world. Their aspiration in creating the ISB is to establish an internationally top-ranked, research-driven, independent management institution that grooms future leaders for India and the world.

The School's Governing Board comprises business leaders, entrepreneurs, and academicians from some of the world's leading business and management education institutions. The school has academic partnerships with the Kellogg School of Management, The Wharton School, and London Business School.

The ISB is uniquely positioned to create this ecosystem for high-technology ventures given its:

- World-renowned faculty

- Linkages with reputed global institutions
- Experienced and high-quality student body
- Association with renowned entrepreneurs and global business leaders
- Dedicated centre for excellence in entrepreneurship
- Relationships with global Venture Capital firms
- World-class infrastructure and facilities

ISB would be supporting start-ups funded by FAST by providing mentoring and start-up management advice using the resources available through its entrepreneurship centre, the Wadhwani Centre for Entrepreneurship Development (WCED). ISB would also leverage its resources and relationships to enable these start-ups manage their IP, access managerial talent with operating, product development, and international business development skills.

The Indus Entrepreneurs (TiE), Hyderabad Chapter

TiE is a global not-for-profit organisation focused on promoting entrepreneurship that began in Silicon Valley. TiE helps budding entrepreneurs by way of advice, guidance and assistance from successful and experienced entrepreneurs and professionals. It has 45 chapters in 10 countries and counts successful entrepreneurs, venture capitalists, angel investors, and business service providers among its members. The Hyderabad chapter of TiE would partner the ISB in creating this ecosystem.

TiE would use its network to facilitate start-ups funded by FAST access follow-on financing, recruit talent with strong operating and start-up experience, and enable them obtain access to potential buyers for their products and services in international markets. TiE would be paid an annual retainer for the support it renders.

Indian Institute of Science (IISc)

The Indian Institute of Science (IISc) is a premier institution of research and advanced instruction in India. It is one of the oldest and finest centres of its kind in India, and has a very high international standing in the academic world as well.

The Institute has been able to make many significant contributions primarily because of certain uniqueness in its character. It is neither a National Laboratory which concentrates solely on research and applied work, nor a conventional University which concerns itself mainly with teaching. The Institute is engaged research in frontier areas and education in current technologically important areas. In keeping with its aims and objects, the Institute has organised a centre for scientific and industrial consultancy through which the know-how generated in the Institute percolates to industries via industry-sponsored projects.

IISc would be supporting start-ups funded by FAST in accessing technology skills needed to support product development. IISc would be paid an annual retainer for the support it renders.

Creating and Managing the Ecosystem

A separate entity would be set up by the ISB at Hyderabad to create and manage this ecosystem. This entity would be manned by persons experienced in working with start-ups. The entity would be responsible for sourcing applications from start-ups, processing them for obtaining financial sanction, and putting together the support mechanism needed by each entity provided seed capital. The activities of this entity would be overseen by Governing Board , Chaired by Secretary, DSIR that will have representatives from DSIR, Partner Institutions, and independent board members of repute.

An Advisory Committee chaired by the Executive Director – WCED at the ISB would also be constituted. The members of this board would include entrepreneurs, VCs, academics, and nominees of DSIR. This board would be the authority empowered to recommend proposals for financial sanction to the DSIR under FAST, and identifying the support needs of entities financed.

ISB would be paid a lump sum fee for putting together this ecosystem and an annual retainer to cover expenses and pay for time committed to this entity.

FAST Scheme – Fund Size

The fund size of FAST – Scheme would be:

- Rs 25 crore for start-up funding
- Rs 50 crore for follow-on funding for R&D purposes

Who can apply?

Start-ups/Small Business intending to create products and services (preferably IP-based) that have their development activities located in India can apply. It is necessary that the IP created be owned by the India outfit.

Quantum and Nature of Funding

FAST would meet the total funds required to establish the proof of concept/develop a working prototype and create the IP needed to take the venture forward subject to a maximum of Rs 25 crore. Funds would not be provided for meeting expenses towards acquiring land and constructing buildings.

FAST would provide funds to the start-up through a mix of grants and interest-free loans.

Where the assessed fund requirement of the start-up is less than or equal to Rs 25 lakhs, the entire amount would be provided as a grant.

Where the assessed fund requirement of the start-up more than Rs 25 lakhs, 50% of the amount would be provided as a grant subject to maximum of Rs. 100 lakh and the balance as an interest free loan.

Funding for further R&D after the concept is proven

In such cases, start-ups and small enterprises can avail a soft loan subject to a maximum of Rs 10 crores per unit. The first Rs 100 lakhs would carry an interest rate of 1% (simple interest) and amount in excess of Rs 100 lakhs would carry an interest rate of 2% (simple interest).

If an established R&D institution is supporting the unit in its R&D efforts, its fee would be paid directly to that institution by the FAST scheme as a grant. The total loan amount to the unit would stand reduced by the amount paid as fee to the R&D institution.

What happens if the VC that had indicated an EOI refuses follow-on funding?

The entity at the ISB would make all reasonable efforts to ensure that the start-up obtains follow-on funding from other sources. If reasonable efforts fail to excite interest in VCs, the failure process will be triggered.

Assessing Failures and Recommending Write-offs

If the start-up fails to meet its commitments in the time frame agreed to, fails to attract follow-on funding because of lack of VC interest, or if the concept fails to meet the requirements of the target market, the start-up would be termed a failure. A Review Committee consisting of a representative from the entity at the ISB, a representative from each partner institution, a Government nominee and an independent technical consultant renowned in the field in which the start-up operates would evaluate the causes of failure. The Review Committee would submit its report to the Advisory Committee.

If the Review Committee determines that failure occurred because of reasons beyond the control of the management and the Advisory Committee agrees with its findings, then it would recommend that the loan, if any pending, be written off by the scheme.

Future Directions

The Government can quickly incorporate learning from this policy experiment to refine the scheme, replicate it in other geographies in India, and also extend it to other sectors with potential. This replication and extension process would lead to the development of strong innovation capabilities in India and to the creation of a pool of start-ups.

The two most important reasons cited for the successful emergence of an early-stage VC industry in Israel are the presence of a critical mass of innovative start-ups (about 300 in number) and strong innovation capabilities (Avnimelech, Kenney, and Teubal, 2004). Therefore, enhanced innovation capabilities and a pool of start-ups can set the stage for the emergence of a vibrant, early-stage VC funding industry in India too.

The Israeli Government did facilitate the emergence of the early-stage VC industry by putting together its highly successful YOZMA programme. It committed USD 100 million towards investment in early-stage VC funds with the rider that the VC take on a local financial institution and an experienced VC with international experience as partners. The international partner complemented the skills of the local partner by bringing in knowledge about VC operations and international experience. Each VC received a maximum of 40% of its corpus through the YOZMA programme subject to a limit of about USD 10 million. The VC fund had the option of buying back Government's investment in it at a pre-determined rate.

Once innovation capabilities are enhanced and a large pool of start-ups created, first phase of FAST Scheme can be closed and second phase of FAST – Scheme can be launched on the lines of YOZMA thereby facilitating the creation of the early-stage VC industry too.

5.3 IPR Programme

S&T Policy 2003

"To establish an Intellectual Property Rights (IPRs) regime which maximizes the incentives for the generation and protection of intellectual property by all types of inventors. The regime would also provide a strong, supportive and comprehensive policy environment for speedy and effective domestic commercialization of such inventions so as to be maximal in the public interest. "

The Policy planners considered Generation and Management of Intellectual Property as an important strategy. In the S&T Policy 2003 it is mentioned that :

"Intellectual Property Rights (IPR), have to be viewed, not as a self-contained and distinct domain, but rather as an effective policy instrument that would be relevant to wide ranging socio-economic, technological and political concepts. The generation and fullest protection of competitive intellectual property from Indian R&D programmes will be encouraged and promoted. The process of globalization is leading to situations where the collective knowledge of societies normally used for common good is converted to proprietary knowledge for commercial profit of a few. Action will be taken to protect our indigenous knowledge systems, primarily through national policies, supplemented by supportive international action.

The development of skills and competence to manage IPR and leveraging its influence will be given a major thrust. This is an area calling for significant technological insights and legal expertise and will be handled differently from the present, and with high priority. “

Following the commitments made at WTO, India has modified IPR related laws and even made new laws such as in the area of Geographical Indication, Plant Variety Protection and Plant Breeders’ Rights. While the laws are in place, exposure to the newly enacted laws is very negligible. There is an urgent need to generate awareness about the new / modified laws in the Indian community particularly scientists including agricultural scientists, technologists, innovators, farmers, academicians and industries. Awareness is required to be generated not only about IPR laws and how to develop / acquire IPRs but also to familiarize them with their rights and obligations.

Due to the changed industrial scenario and globalization of economy, the industry in general and the micro, small and medium enterprises (MSMEs) in particular have to face stiff competition as insulated and protected market conditions are no more available to it. However, through IPRs industry can enjoy the benefit of operating in a protected market conditions because IPRs are exclusive rights.

It is of no use to have IPRs if they are not enforced, may be, if need arises, through the Court of Law. This part of whole IPRs game is much more expensive than acquiring and maintaining IPRs.

For achieving these goals, there are certain issues, which need attention. Therefore, the proposed scheme will address the following issues / problems during the eleventh five year plan.

Problems to be Addressed

The patent literature is an extremely important source of information which is seldom used by our scientific community. Even the industries do not make use of this literature, which can give them enormous information about their competitors, future products likely to enter in the market, solutions to their technical problems by scanning patent literature and improvements in their existing processes / products thereby empowering themselves at the market place.

At the time of formulation of their R&D projects, patent information would help in avoiding any possible infringement of an existing patent. In fact the technical information contained in the patent literature, which is available for free use, can help in suitably devising a new and better product / process.

Further, the innovators have to fully exploit their own IPRs through commercialization by themselves or through licencing of technology. By knowing their rights & obligations through IPRs, they can become smart technology transfer negotiators and whenever & wherever required to take legal action, they can initiate appropriate action to protect their IPRs and indigenous / traditional knowledge.

Objectives:

Objective of the proposed programme is to take up whole range of activities concerning IPRs more rigorously, particularly in view of the strategies given in S&T Policy, 2003 by extending legal, technical and financial support.

The proposed activities of the programme include (but not limited to) the following:

i. To generate awareness of IPRs in the Universities, institutions of higher learning, R&D institutions and industries.

ii. Creating public awareness about IPRs including GI, Farmers and Breeders' Rights, and protection of new plant varieties among research institutes, academic community, universities and industries.

iii. Organizing seminars / workshops on IPR matters in academic institutions, research institutes and industries.

iv. With a view to enhancing competitiveness in the global context, to study and analyze opportunities and challenges faced by the industries in the new IPR regime. This would be done by awarding studies to competent agency / consultants and creating appropriate 'Chairs' in the Universities and institutes of higher learning. Dissemination of IPRs related information is also included.

v. Filing applications for the protection of IPRs in the appropriate IPR offices in India and abroad.

vi. Opposing grant of IPRs, wherever applicable / necessary, in India and abroad.

vii. Utilizing information available in patent and other IPR literature while formulating R&D project(s).

viii. Monitoring trend of innovations through IPR literature.

ix. Monitoring competitors' innovations and their commercial strategies through IPR literature.

x. Monitoring infringements, if any, and to take necessary action for initiating legal action.

xi. Initiating legal action against any possible infringement of IPR in India and / or abroad.

xii. Supporting R&D projects for development of process / product for which application for protection of IPR has been made.

xiii. Commercialization of the process / product for which application for protection of IPR has been made.

It is proposed to provide full financial support by DSIR for the activities at paras (i) to (ix) and partial financial support (50%) of the total project cost for the activities at paras (xii) and (xiii).

Target Beneficiaries**:**

Scientists working in Universities, institutions of higher learning, R&D institutions, agriculture sector and industries.

Mechanism of Operation:

The programme is proposed to be operated by DSIR. The details of the mechanism and other aspects would be worked out in due course.

Budget : Total Rs. 100 crore

Filing:

Country	**No. of applications per annum / 5 years**	**Total (Rs. in lakhs)**
India	10/50	25.00
PCT	5/25	45.00
USA	5/25	250.00
Europe	5/25 (in 5 countries=125)	530.00
Japan	5/25	300.00
	Total	**1150.00**

Other Activities:

Activity	**Expenditure (Rs. in lakhs)**
Awareness generation (4 seminars p.a. @Rs.5 lakhs)	100.00
Supporting R&D projects for which IPR application made	3000.00
Supporting commercialisation (including R&D activity) of patented inventions (50% support; 2 cases p.a. ;DSIR support ~ Rs. 5 crores)	5000.00

Studies & Chairs (4 for 5 years) IIM, National Law School, Indian Society of International Law, DSE, etc.) and procuring IPR related softwares and their licensing (Salary ~Rs.50000/- p.m. + University overheads)	700.00
Monitoring trends of innovation (Rs.5 lakhs p.a.)	25.00
Evaluation/Analysis of alleged infringements	25.00
TOTAL	**8850.00**

The above heads are given only to broadly explain the basis / activities. In actual practice, the budget utilization may interchange (inter-and/or intra-headings).

6. Central Electronics Ltd.

6.1 S&T Scheme

(i) To develop new SPV applications particularly in the areas of lighting and signaling exploiting **White** LED technology

(ii) To develop and identify process technology for the production of thin film silicon solar cells and modules, as possessing an alternate technology keeping in line with current technology trends globally and also with a view to adopt this technology for commercial production.

(iii) Solid State Interlocking, microprocessor based MUX, Universal Fail Safe Block Interfacing (UFSB), Auxiliary Warning System (AWS), EVM and LED Based Signals

(iv) Rotating Field Phase Shifter, Development of Piezo based materials, products and fuses for defence applications.

Proposed Outlay For 11th Plan:

(Rs.in Crores)

Scheme Plan	2007-08	2008-09	2009-10	2010-11	2011-12	11^{th} Plan
S&T Plan	5	8	5	5	5	28

6.2 I&M Scheme

The solar PV market has been growing at a rate of 40% since last 3-4 years, and is likely to grow at a rate of 25% per annum for next 5-10 years. With this rate the global market is likely to exceed the annual production mark of 12 GW during the year 2012. Likewise, the Indian market demand is expected to reach 200MW by the year 2012.

CEL will target the production of Solar Cells and Modules upto 25 MW per annum by the year 2012. The main emphasis will be to establish/state of the art process technology, to enhance the productivity and conversion efficiency. CEL is in the process of establishing in-line manufacturing/testing facilities by year 2012.

Safety being the highest priority in Indian Railways, large-scale deployment of modern signaling & safety equipment is envisaged. The present infrastructure will be upgraded so that the stringent specifications and requirements not only of Indian Railways but also international level to generate export are met. CEL will acquire sophisticated latest production equipment (CAM) for the Systems Production with an objective of minimizing failure rate and improving MTBF of the products. The design of the products will be continuously improved, keeping in pace with trends in the components and technology.

Defence is likely to induct Weapon Locating Radar and Akash Missile in large number during XI Five Year Plan. To meet the projected demand, the manufacturing/testing facilities of Phase Control Modules (PCM) etc. are need to be augmented to manufacture 30,000 to 40,000 Nos. PCM annually.

Production plan for 11th five year plan

Rs. in crores

2007-08	2008-09	2009-10	2010-11	2011-12
192.75	218.13	232.88	250.00	250.00

Proposed Outlay for 11th plan

Rs. in crores

2007-08	2008-09	2009-10	2010-11	2011-12	11th Plan
4.00	6.00	3.00	2.00	__	15.00

Manpower Employed:

	As on 31.3.2006	2007-08	2008-09	2009-10	2010-11	2011-12
Scientific & Technical	480	460	460	450	450	450
Administration	115	100	100	95	90	90
Supporting Staff	81	65	65	65	60	60
Total	676	625	625	610	600	600

7. National Research Development Corporation

7.1 Invention Promotion Programme — Rs. 100 crore

Continuation of on-going programmes

S.No.	Particulars	11th Plan
1.	Prize awards for meritorious inventions	2.50
2.	To bring out scientific publications like Invention Intelligence (English bi-monthly magazine), Awishkar (Hindi monthly magazine) including mail version of Invention Intelligence	7.00
3.	Assistance for patenting inventive ideas and Providing financial assistance for the fabrication and testing of models or prototypes of commercially viable inventions/new ideas,	9.00
4.	Techno-commercial support to promising inventions including incentive to scientists for making know-how documents and demonstration of technology	10.00
5.	Patent awareness seminars	1.00
6.	On-line patent search	0.50
	Total	30.00

New Initiatives

S.No.	Particulars	11th Plan
1.	Incubation and Venture Capital Funding for promoting development of new generation products	50.00
2.	Information related to NRDC awarded inventions on Web and their regular updating.	4.00
3	IP Business Initiatives – Basic Engineering Design Packages	10.00
4	Consultancy/Man-power Cost	6.00
	Total	70.00

Incubation and Venture Capital Funding for promoting development of new generation products

NRDC realizing that there is an urgent need to convert discoveries into development at a faster rate is proposing to initiate a mechanism of Venture Capital Funding to promote development of new generation products through acceleration of technology development process by the proposed initiative to be taken during the 11th Plan. Thus in order to supplement the technological entrepreneurial base in the country, NRDC started a pilot scheme of VCF in the year 2006-07. Through this scheme NRDC aims to further encourage technologist, technocrat and professionals to take up new and risky ventures.

NRDC proposes to continue the pilot scheme of VC funding as a proactive step to give a boost to existing climate whereby such technologies development can be initiated and promoted and provide a much needed risk cover to entrepreneurs, willing to work with such lab technologies. Wherever necessary, Venture Capital Funding for incubation of technology would also be provided at the pilot scale so that further opportunity gets created for successful development of such technologies.

The scheme is to :-

- Provide VCF to NRDC licensees/ promising inventions

- Provide a part of the associated capital required for implementing the widest possible range of industrial projects.

- Encourage new entrepreneurship which shall facilitate setting up of the knowledge based industries.

- Promoting untapped technological opportunities for funding

Objective of the Scheme

The objective of the scheme is i) to further encourage, even the first generation entrepreneurs, in order to enlarge the technological entrepreneurial base in the country and ii) to provide assistance in soft terms to those entrepreneurs who are willing to undertake risk oriented project entailing the use of advanced and/or complex technology or projects for the manufacture of new products for new application.

Financial Outlay:

The requirement of the funds for undertaking the activity Incubation and Venture Capital Funding for the 11th Plan are as follows:

(Rs in crores)

	2007-08	2008-09	2009-10	2010-11	2011-12	Total
No. of ventures to be supported *	8	8	9	10	10	45
Amount	7.50	7.50	10.00	12.50	12.50	50 .00

Basic Engineering Design Packages for licensed technologies

Today's industry prefers complete technology package which contain Basic Engineering Design Package so that they can scale it up further and put up the commercial plant. Once the Basic Engineering Design Package (BEDP) is prepared one can work out for detailed engineering for setting up the pilot plant and successful operation of the process at the pilot plant. Based on the experience gained during 2006-07, Corporation shall take up the work for development of BEDP of the various potential technologies some of which are in demand both in India and abroad and required considering the tomorrow's need for cleaner environment.

The Corporation proposes to build up resources of the various books, data, information along with procurement of imported process simulation software like Chemcad suite Aspin Plus batch etc. which help in preparing basic engineering packages and setting up of pilot plants for up-scaling laboratory based know-how. Corporation would develop basic engineering packages in the following manner

Financial Year	2007-08	2008-09	2009-10	2010-11	2011-12	Total
No. of packages	5	5	8	10	12	40

Financial Outlay: The proposed financial requirement for carrying out the activity “Basic Engineering Design Packages for licensed technologies” in the 11th plan period would be as under:

(Rs. in Crores)

Financial Year	2007-08	2008-09	2009-10	2010-11	2011-12	Total
Amount	0.5	1.5	2.00	2.50	3.50	10.0

7.2 Technology Promotion Programme Rs. 68 crore

i. Promotion of Rural and Household Technologies

On-going programmes:

Rs. Crore

S.No.	Particulars	11^{th} Plan
1	Strengthening of existing RTDT Centre	4.00
2	Setting up of new RTDT Centres	2.00
3	Wide Publicity to appropriate technologies by participation in Rural Exhibitions and advertisements	2.00
	Total	8.00

New Initiatives (Rural Clusters in Dairy and Sericulture)

Rs. Crore

S.No.	Particulars	11thPlan
1	Identification of important tecgnological gaps and need, prepration of technology modules in local language, training and demonstration,, literature printing, field trials, publicity etc.	5.00
2	Consultancy/Man-power Cost	4.00
	Total	9.00

ii. Promotion of Export of Technology

On-going programmes

S.No.	Particulars	11^{th} Plan
1	Participation in exhibitions and technology promotion conferences abroad [@ six exhibition/year]	7.00
2	Printing, advertisement and publicity related to promotion of export of technologies	1.00
3	Knowledge Management System for identification of export of technologies	2.00
4	Multimedia presentation of small and micro machineries and technologies	1.00
5	Consultancy/Man-power Cost	3.00
	Total	14.00

New Initiatives

S.No.	Particulars	11^{th} Plan
1	Setting Up of Offshore Demonstration Units of Indian Technologies and Machinery	7.50

iii. Informatics for Technology Transfer

S.No.	Particulars	11^{th} Plan
1	Participation in exhibitions/seminars/workshops	2.00
2	Co-sponsoring seminars/workshop/get-togethers	0.50
3	Market Surveys	1.00
4	Updating the Website	2.00
5	Books, periodicals	1.00
6	Software	4.00
7	Printing of publicity materials related to technology dissemination	2.00
	Total	12.50

iv. Technology Development Programme for Priority Projects

On-going projects

- Further Development work on the patented process on Targeted Gene Delivery System for developing various therapeutics in association with Albert Einstein College of Medicine, New York, USA
- Hydrogenation of Azadichtrin
- Shelf Life Extenders for fresh fruits and vegetables
- Vaccines
- Bio-diesel

- Bio-pharmaceuticals

A sum of Rs.10.00 Crores is required for carrying out these developmental projects during 11^{th} Plan.

Women Entrepreneurship Development Program

- Selection of NGO and identification of site
- Procurement of need based machines and establishing training facilities
- To exhibit and demonstrate machines/ technology appropriate for Women
- Preparation of multimedia presentation, manual/ training brochures, printing of catalogues
- Organising workshops, seminars/ hands on practice at different locations in the Country
- Providing necessary consultation and other services for setting up of Industries
- Assisting in getting loan from financial institutions

A sum of Rs. 2 crores will be required in 11^{th} Plan for this activity.

Programme for North-Eastern States

NRDC plans to set up Demonstration centers at 3 locations of appropriate technologies/machineries related to :

- Biodiversity conservation technologies
- Post harvest technologies
- Food processing units
- Alternate source of energy

The above activitiy has to be carried out under mission mode approach. It is not necessary that the development of such technology should be carried out in a research institute of the area rather NRDC will act as a bridge and identify an Institute even locally and if not then in the country which is more advanced and most competent to carry out further developmental work. All such development of technology will be under mission approach basis which require a holistic approach with adequate funding arrangement.

In order to achieve these objectives awareness seminars and the training programmes would be organized in each state on a repetitive basis so that the thought process of the intellectual of the area should be focused on conservation and protection of bio-resources thereby bringing monitory benefits to the local public needing of the economic development of the each state. Training programmes and geographical indication registration and sensitization programmes shall also become a part of the activity.

Financial Outlay for this Scheme

Rs. 5.00 crores will be required for carrying out "New initiatives for North Eastern states" as per the details given below:

NRDC 11th plan Outlay in a Nutshell

Rs. Crore

S.No.	Continuing Schemes	Financial Outlay
1	Invention Promotion Programme	**100.00**
2	Technology Promotion Programme	
(i).	Development and Commercialisation of Rural Technology (Renamed to Promotion to Rural and Household Technologies)	17.00
(ii).	Export of Technology	21.50
(iii)	Informatics for Technology Transfer	12.50
(iv)	Technology Development Programme for Priority Projects for the larger benefit of the Nation	17.00
	TOTAL (TPP)	**68.00**
	TOTAL	**168.00**

8. Consultancy Development Centre

Proposed activities for 11th plan are given below:

(i) Consultancy Services Export Promotion Programme

During the last few decades India has developed considerable expertise and capabilities in consultancy, which can match international standards. The country has the necessary scientific and technological human resource and managerial expertise available in sufficient numbers for providing consultancy services including in advanced countries. Also, the reputation of effective delivery and low costs as compared to those in developing countries is an added advantage. This has led to opening up of new opportunities for Indian consultants and consultancy organizations in the global market, especially in the present environment with WTO providing an effective forum to influence global trade policies. In this situation, necessary mechanism should be evolved to effectively utilize the opportunity.

CDC is currently the Secretariat of the Technical Consultancy Development Programme for Asia and the Pacific (TCDPAP). This is a programme promoted by UN-ESCAP and supported by the DSIR for developing consulting capabilities at National, Sub-Regional and Regional levels in the Asia and Pacific Region. The programme initiated in 1994 comprises 13 Countries of Asia and Pacific region as members. CDC is the secretariat for implementing programmes of TCDPAP, which is guided by a General Council and Executive Committee. Over the years the Secretariat has carried out activities like training and skill building programmes in various countries, Annual Conferences every year in one of the member countries, develop linkages through networking, publication of newsletter, proceedings of annual conference and so on. It is proposed to develop this activity as a Centre of excellence for facilitating export of Indian consultancy services to the Asia Pacific and other countries. The activities to be carried out through the proposed Centre shall comprise the following: -

- Identification and analysis of potential markets
- Conduct studies on issues related to consultancy services exports
- Organize exchange visits of delegations to prospective countries
- Publish compendiums on Indian consultancy expertise
- Publish compendiums on Indian consultancy expertise
- Develop a mechanism for facilitating Knowledge Process Outsourcing
- Organize training and skill building programmes

(ii) Consultancy Information, Research and Programme

It will be useful to evolve a research programme with focus on the consultancy profession dealing with issues relating to consulting, its operational dimensions, practices of consultancy services, client consultancy relationships, etc. The activities to be undertaken by the research facility will comprise

- Analytical Studies on consulting needs and trends with emphasis on SMEs
- Sectoral State-of-the-art reports
- Status reports on export promotion opportunities
- Journal on Consulting
- Publications
- Training and skill building on emerging trends

(iii) Training and Skill Building Programmes

Presently the Centre conducts a number of training and skill building programmes. These will be reoriented in line with the changing trends indicated in the vision/status reports. This area be given more thrust with quantum increase in the number of programmes with focus on emerging trends in various sectors including outsourcing and consultancy exports. Specialised programmes will also be planned and executed for various R&D organizations, consultancy and client organizations and other professional organizations. It is also proposed to design and develop certification programmes for consultants on the lines of Certified Management Consultant (CMC) programme of IMCI. The MS degree programme will be developed in a more focused way with practical orientation and the reach will be spread to other cities through evolving on-line programmes.

Budget

Activity	**Outlay (Rs. Crore)**
Consultancy Services Export Promotion Programme	4.00
Consultancy Information, Research and Promotion	5.00
Training and Skill Building	1.00
Total	**10.00**

ANNEXURE 1

No. DSIR/TPDU/XI Plan/07(1)/2006-07
Government of India
Ministry of Science and Technology
Department of Scientific and Industrial Research

Technology Bhavan
New Mehrauli Road
New Delhi – 110016
July 07, 2006

ORDER

Subject: Constitution of a Working Group for Formulation of 11th Plan Proposals of Department of Scientific and Industrial Research

In the context of formulation of the Eleventh Five Year Plan (2007-2012), it has been decided to set up a Working Group for the Department of Scientific and Industrial Research (DSIR). The terms of reference and the composition of the Working Group will be as follows:

I Terms of Reference

1. To review the performance, present status and growth of industrial research and technology development in the country, keeping in view the current economic scenario, emerging trends and the targeted goals.

2. To review the targets vis-à-vis achievements of the departmental plan scheme during the tenth five year plan.

3. To suggest new incentives and mechanisms to encourage industrial research and enhance industry's share in country's R&D expenditure.

4. To suggest innovative mechanisms for supporting and funding new technology development and its speedy commercialization.

5. To evolve efficient mechanisms for capturing the innovative spirit of individuals and hand-holding them for translating their innovative ideas into usable products.

6. To suggest mechanisms for facilitating Indian scientists, technologists, institutions and organizations in their endeavour to commercialize patents filed in India and abroad.

7. To evolve mechanisms for technological capability building of industry.

………..Cont'd 2/-

8. To evolve mechanisms for accelerating the growth of consultancy profession for catering to the domestic as well as export markets.

9. To enhance the share of technology intensive exports in India's export basket as well as enhance India' share of global technology exports.

10. To suggest mechanisms for innovation management and efficient utilization and management of technologies (available with institutions and research establishments) by industry. Also, to promote integration of technology strategy with business strategies in industry.

11. To suggest mechanisms for enhancing FDI for industrial research and technology development in the country.

12. To assess the needs and viability to develop a comprehensive system on S&T information to support industrial research and technology development in the country.

13. To evolve innovative schemes for departmental PSU - National Research Development Corporation.

14. To suggest mechanisms and schemes for turning around the departmental PSU – Central Electronics Limited.

15. To evolve innovative schemes for autonomous organization of the department – Consultancy Development Centre.

II Composition of the Working Group

1. Secretary, DSIR - Chairman
2. Representative of Department of Science and Technology
3. Representative of Department of Bio-Technology
4. Representative of Department of Commerce
5. Representative of Department of Information Technology
6. Representative of O/o Development Commissioner for SSIs
7. Representative of Planning Commmission
8. Representative of Ministry of Women and Child Development
9. Dr. K.V. Raghavan, Chairman, RAC (DRDO) and former Director, IICT
10. Mr. Sujit Banerjee, President, Reliance Industries
11. Dr. M.D. Nair, Former MD, SPIC
12. Representative of Confederation of Indian Industry
13. Shri Rajan Kohli, Dy. Secretary General, FICCI
14. Shri A.T. Kusre, GM, ICICI

……..Cont'd 3/-

15. Shri N.V. Satyanarayana, CMD, Informatics India
16. Representative of Industrial Design & Development Centre, IIT Delhi
17. Shri K.K. Kapila, Inter-Continental Consultants
18. Dr. Ashok Barua, Former Director, IACS
19. Dr. O.P. Agarwal, Emeritus Scientist, ICMR
20. Shri Ashwani Gupta, Scientist "F", DSIR - Member Secretary

2. The Chairman of the working Group may include additional terms of reference, in consultation with the members.

3. The Chairman of the Working Group may co-opt any other expert as member of the Working Group, if considered necessary.

4. The Chairman of the Working Group may consider and grant permission to invite FA, DSIR, all the departmental officers of the level of Scientist "G", CMDs of NRDC & CEL, departmental officer in-charge of PSUs and DG, CDC as "invitees" to the Working Group Meetings.

5. The Working Group will submit its report to the Chairman of the Steering Committee on Science and Technology before 31st August, 2006.

6. The expenditure on TA/DA of official members in connection with the meetings of the Working Group will be borne by the respective Department/Ministry to which the official belongs, as per rules of entitlement applicable.

7. The non-official members shall be paid an honorarium of Rs. 1000/- (Rupees One Thousand Only) per day for the days of the meetings.

8. The non-official members of the Working Group shall be entitled to airfare by entitled class, actual taxi fare for local journeys and DA as per the following rates.

City	**where non-official stays in Govt./Public Sector Guest House**	**makes his own arrangement**
A-I Class	Reimbursement of actual expenses for lodging + Rs. 195/-	Rs. 260/-
A Class	Reimbursement of actual expenses for lodging + Rs. 157/-	Rs. 210/-
B-I Class	Reimbursement of actual expenses for lodging + Rs. 127/-	Rs. 170/-
Others	Reimbursement of actual expenses for lodging + Rs. 101/-	Rs. 135/-

…….Cont'd 4/-

9. This issues with the approval of Secretary, DSIR vide their Dy. No. 1321 dated 03.07.2006 and with the concurrence of IFD vide their Dy. No. 107 -FA(DSIR) dated 03.07.2006.

Yours faithfully,

Sd/-

(S.BANERJEE)
Scientist 'G'

To,

Chairman and all the Members of the Working Group

Copy to:

1. PS to Chairman of Steering Committee on S&T
2. PS to Member(Science), Planning Commission
3. PS to Member-Secretary, Planning Commission
4. PS to JS (Plan Finance), Ministry of Finance
5. PS to FA, DSIR
6. All Scientist "G" in DSIR, CMDs of NRDC & CEL, Departmental Officer in-charge of PSUs and DG, CDC
7. Pay and Accounts Officer, Ministry of Science & Technology
8. Drawing & Disbursing Officer, DSIR

Sd/-
(S.BANERJEE)
Scientist 'G'

ANNEXURE 2

MINUTES OF FIRST MEETING OF THE WORKING GROUP FOR FORMULATION OF DSIR'S ELEVENTH PLAN PROPOSALS HELD ON 31ST JULY 2006 AT 2.30 P.M. IN CSIR, NEW DELHI

A Working Group Meeting to discuss the 11th Plan proposals of DSIR was held under the Chairmanship of Secretary, DSIR in CSIR Headquarters, New Delhi on 31st July 2006 at 2.30 p.m. List of participants is at Appendix.

At the outset, various officers of DSIR, NRDC, CEL and CDC made a brief presentation on the 11th plan proposals.

The observations/comments made by Committee Members thereafter and also comments sent subsequently in writing by some members are summarized below.

1. **The Chairman,** Secretary, DSIR said that DSIR is a small but very effective department. The role played by it is catalytic in nature and with its small budgetary support, it is able to establish linkages with a large number of research institutions and industrial units and encourage them to take up a number of projects of large commercial impact. He added that recognition of 1200 in-house R&D units of industry and 550 Scientific and Industrial research Organizations (SIROs) by DSIR brings it very close to industry and it is thus in a position to appreciate their concerns better. Therefore, DSIR is the most appropriate department to design programs that facilitate industrial research and technology development. He recognized that some of the on-going programmes of DSIR need a step-up e.g. TePP, International Technology Transfer and Technology Management. The chairman emphasized the importance of Public Private Partnership (PPP) wherein the programs will be catalyzed with public funds and monitored by public authorities but will be managed privately. Commenting on new initiatives proposed for the 11th plan, he said that the schemes of Small Business Innovation Research Initiative (SBIRI) (in areas other than bio-technology) and Global Research and Industry Partnership Fund (GRIPF) are good initiatives and are being discussed in various meetings and forums. GRIPF is about acquiring technology from abroad instead of developing it on our own and makes lot of sense in today's scenario.

   Appreciating that it would be unfair to expect comprehensive on-the-spot comments from members on DSIR proposals, he requested the members to take their time and e-mail their comments on the proposals with in a week's time.

2. Dr. M.D. Nair's comments on various programmes of DSIR were as follows:

   - Utilisation of funds under all the DSIR on-going programmes are below the approved outlays during the 10th five year plan. The programmes should be reviewed and fresh priorities should be set for the effective implementation of those of high priority. Promotional activities should be focused on an identified target group and a cost to benefit analysis should be carried out using identified milestones and benchmarks.

- A detailed analysis of the business model that NRDC wants to adopt during the 11th plan needs to be carried out to ensure that this premier organisation is not only a technology transferor, but also the fountain head of applied R&D to develop commercially relevant products. It was suggested that NRDC may like to study the style of functioning of British Technology Group, the technology transfer company in UK and take up programs which promote licensing and commercialization proactively.

- With reference to SBIRI proposal and supporting small business innovation, he said that DSIR should take the lead in legislating the grant of Petty Patents to protect incremental innovations, which are of great significance to industry, a strategy adopted by many countries in both the developed and developing world. The sum total of the innovations protected by petty patents could be a major intellectual asset for the Country.

- With reference GRIPF proposal, he said that documentation and analysis of portfolios of Patents in select technology areas need to be prepared in all essential details and an agency created for not only evaluating them, but also accessing them for industrial use as well as for fresh R&D efforts with a view to create patentable innovations.

- Success of FAST scheme will depend upon the ability of the fund management to dentify potential technology winners for which an advisory group with intimate knowledge of both technology and business components should be set up.

- IPR awareness programmes need to permeate further to a wider section of the industrial segments, particularly in the SME sector.

- CDC needs to be revisited and fresh plans made to have an organization which would be productive and beneficial apart from being commercially viable. Since consultancy is an area where the private sector has successfully made major inroads, unless there are some special USPs, CDC's overall role will be questionable. The CDC should be a profit Centre and self sustaining if it is to be continued.

Dr. Nair further opined that India can definitely become an innovation hub provided we focus in select areas, where we have a niche and can make a difference.

3. Dr. A.K. Barua expressed his concern about the shortage of silicon and said that a silicon producing plant may be set up in the country. He added that CEL must work on new technologies for solar cells in the 11^{th} plan.

4. Shri Kapila stressed on the need to strengthen the Technical Consultancy Development Programme for Asia and Pacific (TCDPAP) for which CDC is the secretariat. He also talked about developing a database of consultants and consultancy organizations working in the region who are in a position to take advantage of the global consultancy opportunities. It was added that TCDPAP should undertake training and skill up-gradation of consultants in the region on a regular basis. He also suggested TCDPAP membership may also be thrown open to corporate and individual consultants of the member countries besides consultancy organizations and necessary funds may be allocated for TCDPAP in the 11th plan.

5. Dr. Raghavan said that DSIR programmes need to be integrated into national innovation efforts. Special focus should be on commercialization and export promotion of novel products/processes in frontier areas such as nanomaterials, micro-nano composite devices, electroceramics, novel drug delivery systems, bio-photonics, sensing & imaging, renewable energy systems, novel hydrogen generation systems, etc. DSIR programmes should facilitate multi level collaborations and partnerships, easier access to resources and capabilities in public research institutions and faster commercialization of ideas. As regards Technology Development and Demonstration Programme, it was suggested to reduce the interest rate to 1%, to increase DSIR support up to 80% of project cost depending upon technological capabilities of beneficiary industry and give priority for scaling up of globally patented know-how by Indian industry. Scaling up of lab scale know-how in areas such as nano, bio, new energy, new materials and waste utilization was suggested. Also suggested was linking up with schemes such as TDB and support scale up of pre-commercialization phase of projects, as identified by experts. Also suggested was commercialization of university research towards product/technology development in areas such as healthcare, cosmetics, material science, microelectronics, micro-machines and photonics. He emphasized the importance of public private partnership and said that SBIRI is a good proposal. He further mentioned that DSIR can play an active role in commercialization of spin-off technologies from atomic energy, defense and space sectors. He also emphasized on the need to develop appropriate technologies for the North-East.

6. Lt. Gen. Mehta said that we must maintain information on Technology Deficits in the country so that we can focus on right kind of technology to be supported for development or acquisition. It was stated that Aerospace technology is the mother of all technologies and needs to be appropriately supported. He stressed on building a weather forecasting model which will help in disaster mitigation and conservation of natural resources. Building high tech clusters on the Cambridge model was also suggested. Lastly, he said that SMEs are excited in the present industrial scenario and need to be supported through appropriate Public-Private Partnership model.

7. Dr. A.T. Kusre stated that ICICI would like to be the partner in schemes where there is a provision for early stage financing. He also said that there is a need to step up the Technology Management Programme.

8. Shri N.V. Sathyanarayana said that there is no Google like portal for patent literature and therefore, proposed that DSIR should develop a portal on PPP model which has free access to all and is simple and easy for end-user navigation. He added that global information industry is a major sector of the industrial economy and is estimated at round US$310 billion (2006). Science & Technology information sector constitutes 5% of the industry, estimated at over US$ 15 billion. There is scope for building S&T information sector in India on a global scale on PPP model. Shri Sathyanarayana cited two major long-term benefits from investing in this sector: (a) visibility of Indian S&T potential and initiatives in global mainstream; and (b) India emerging as a competitive alternative in global S&T information segment.

9. Shri Arya mentioned about the schemes of DCSSI for supporting and funding SMEs. He talked about Rs. 960 crore scheme following the recommendations of National Manufacturing Competitiveness Council (NMCC) wherein 500 clusters are to be supported for lean manufacturing and 225 clusters for industrial design. He said that DSIR's help is needed to transfer the technology and train the consultants for supporting these clusters.

10. Dr. Lalit Das said that DSIR and its units are essentially propelled by able scientists and technologist. It has negligible designers who understand the conversion process from technology to marketable products & services and entrepreneurial managers who can create and understand organizations that mass produce and deliver products and services. He stated - what is required is a shift from technology transfer to 'Transfer of Technology cum Design Package'. He mentioned that export of handicrafts including hand knotted carpets from India amounted to over $3.5 billion in 2004-05 which is merely 2% of the global market for handicraft exports. He urged DSIR to consider providing quality testing, technology development, design and entrepreneurship generation facilities in all major handicraft clusters.

11. Shri Mittal said that we need support innovations the way it is done at the ignition centers in MIT, USA. He added that for development of rural technologies, costs incurred by rural entrepreneur in availing the services of labs and institutions need to be subsidized. He also stated that networking with other ministries is required for optimum utilization of resources.

12. Dr. Amit Biswas mentioned that we need to carry out IP landscaping and judiciously determine gaps that can be plugged by DSIR. He talked about IP analysis and developing skills to write patents. He said that GRIPF is a good initiative and for implementing the initiative, we can perhaps learn from China. It

was stated that China is the only country which has been able to convert nano-technology into business. He suggested Indian companies co-operating with emerging Chinese companies. Lastly, he talked about 6-sigma or in other words measuring or quantifying innovations so as to decide and prioritize, which ones to support.

13. Dr. Gopal said that NRDC's Rural Technology Demonstration cum Training Centres can play a useful role in providing employment to women and development of women entrepreneurs.

14. Dr. O.P. Agarwal ICMR supported NRDC's proposed venture capital funding initiative to promote development of new generation products.

15. Shri John Thomas said that SMEs should build technology as a resource through joint research programmes.

16. Dr. Renu Swarup said that SBIRI in areas other than bio-technology is a good initiative but efforts should be made to avoid overlaps since biotechnology cuts across various disciplines. It was suggested that the possibility of strengthening the IPR system in terms of human resource as well as infrastructure, especially in university system should be explored. She added that under the Techno-entrepreneur Promotion Programme, there should be a special thrust on grass root innovations.

After listening to everybody's comments, the Chairman, Secretary, DSIR thanked everybody for their useful contributions. He said that an internal meeting would be held in DSIR to give definite shape to the DSIR's 11th plan proposals which would be discussed in the next meeting.

The meeting ended with thanks to the Chair.

APPENDIX

<u>LIST OF PARTICIPANTS</u>

1. **Dr. R.A. Mashelkar, Secretary, DSIR - Chairman**

2. Shri H.K. Mittal, DST
3. Dr. Renu Swarup, DBT
4. Shri J.K. Arya, DCSSI
5. Dr. A.K. Gopal, Director (NIPCCD), M/o of Women & Child Development
6. Dr. K.V. Raghavan, Chairman (RAC), DRDO
7. Dr. Amit Biswas, Reliance Industries Limited
8. Dr. M.D. Nair, Consultant to Pharma Industry
9. Lt. Gen. S.S. Mehta (Retd), CII
10. Shri Anjan Das, CII
11. Shri John Thomas, FICCI
12. Shri A.T. Kusre, ICICI
13. Shri N.V. Sathyanarayana, Informatics India Limited
14. Dr. Lalit Kumar Das, I.D.D Centre, I.I.T Delhi
15. Shri K.K. Kapila, Intercontinental Consultants and Technocrats Pvt. Ltd.
16. Dr. Ashok Barua, Indian Association for Cultivation of Science
17. Dr. O.P.Agarwal, CSIR Emeritus Scientist, ICMR
18. Dr. A.S. Rao, DSIR
19. Shri R.R. Abhyankar, DSIR
20. Smt. S. Ravindran, DSIR
21. Smt. Jyoti S.A. Bhat, DSIR
22. Shri Subrata Banerjee, DSIR
23. Shri Rajkumar, DSIR
24. Dr. S.K. Kulshrestha DSIR
25. Dr. K. Kamal, DSIR
26. Shri Vibhu Rashmi, DSIR
27. Shri K.V.S.P. Rao, DSIR
28. Shri Rakesh Bhartiya, DSIR
29. Shri Somenath Ghosh, CMD, NRDC
30. Dr. S.K. Kaicker, CMD, CEL
31. Shri Deepak Agarwal, DG, CDC
32. Shri S.V. Subbarao, CDC

33. Shri Ashwani Gupta, DSIR - Member Secretary

ANNEXURE 3

MINUTES OF SECOND MEETING OF THE WORKING GROUP FOR FORMULATION OF DSIR'S ELEVENTH PLAN PROPOSALS HELD ON 29th AUGUST 2006 AT 11.30 A.M. IN CSIR, NEW DELHI

Second meeting of the working group to discuss the 11th Plan proposals of DSIR was held under the Chairmanship of Secretary, DSIR on 29th August, 2006 at 11.30 a.m. in CSIR Headquarters, New Delhi. A list of participants is given at Appendix 1.

1. The meeting started with a discussion on the minutes of the first meeting held on 31st July, 2006. Highlights of the discussions held are given below:

i. Regarding carrying out cost-benefit analysis of DSIR programs, the Chairman, Secretary, DSIR suggested that parameters for evaluation of the performance and outcome of scientific and technical work/schemes need to be clearly defined because the benefits that accrue from scientific and technical work/schemes are tangible as well as non-tangible. In this connection, he referred to Kelkar Committee Report on performance analysis of CSIR laboratories and suggested DSIR or the agency, which is assigned the responsibility to conduct cost-benefit analysis to consider the recommendations made in the Kelkar Committee Report.

ii. Regarding "legislating grant of petty patents", it was stated that this subject comes under the purview of Department of Industrial Policy and Promotion (DIPP) and accordingly, a letter may be sent to DIPP for their consideration and necessary action.

iii. Regarding "measuring and quantifying innovations", it was clarified that there is a need for evolving a systematic mechanism for proper screening of innovative ideas so as to segregate those ideas which have the potential to go through the process of pilot up-scaling and commercialization. This would help in proper utilization of funds and resources in supporting innovations.

iv. The suggestions made regarding Technology Development and Demonstration Programme, viz. reduction in interest rate of repayment of funds to 1%, increasing percentage of DSIR support to 80% of project cost, and focus on the identified thrust areas were agreed to. It was added that DSIR support in this programme is not restricted to SMEs or small businesses but can be extended to large scale companies also. Further, it was agreed that DSIR support may not be restricted to companies alone but may also be extendable to public funded institutions.

v. Regarding setting up a Google like Science Portal, it was said that it would create a new market in the global S&T information market place and it is the most opportune time for launching such an initiative on a PPP model.

vi. On NRDC, it was said that NRDC must proactively source new technologies that have higher commercialization potential.

vii. On self sustenance of CDC, the Chairman enquired about the dependence of CDC on government grant. It was stated that CDC's dependence on government grant has reduced to around 35% today compared to around 80% about 3 years ago.

viii. As regards transition of the country from the status of technology recipient to technology donor, formation of Chartered Technology Auditors and a resource pool that would tap the un-codified knowledge available with experts in various spheres of life was suggested.

Having confirmed that everybody's views and observations have been adequately addressed, the Chairman took up discussions on the 11th plan proposals of DSIR.

2. The TePP proposal stated that 10,000 new ideas would be accessed and 1,000 innovations would be supported. It was clarified that 10,000 ideas imply raw ideas and whether they are new or not would be assessed only after scrutiny. Thus, it was said that "new" may be deleted from "new ideas" used in the proposal. Further, it was added that creativity may be promoted in existing institutions such as NIF and through activity based support rather than establishing a new institute.

3. Regarding International Technology Transfer Programme, it was stated that Indo-Australian Bi-national Industrial Research and Development (BIRD) programme would be implemented by DSIR. DSIR would participate in the collaborative projects between Indian and Australian industries for which Australia has committed about 2 million Australian dollars. The BIRD fund would help in development and subsequent commercialization of innovative technological products and processes from which both, Australian and Indian companies can expect to derive benefits commensurate with investments and risks. Grant from BIRD fund would have to be paid back with interest if revenues are generated from the R&D project.

Further, it was pointed out that merchandize export target for 2006-07 is US$ 126 billion instead of US$ 120 billion mentioned in the background document circulated for the meeting.

4. Regarding the new initiative, viz. Fund for Accelerating Start-ups in Technology (FAST), it was said that this initiative is to prepare companies for venture capital funding. The Indus Entrepreneurs (TIE), Hyderabad chapter, which is proposed to be a partner in the initiative will provide the necessary guidance for venture capital funding.

5. Regarding the new initiative, Small Business Innovation Research Initiative (SBIRI), it was said that the title need not specify "in areas other than bio-technology" but adequate care to be taken to avoid overlaps with DBT scheme. It was stated that projects in traditional sectors in which there is lack of application of new technology such as coir, spices and cashew processing may be also supported under SBIRI. Further, there

should be no bar on supporting inter-disciplinary projects by DSIR where bio-technology is a minor component in the overall project. It was also suggested that implementation of the scheme in DBT may be carefully studied so as to identify areas which have hindered the implementation of the scheme (e.g. definition of small business viz. that employing up to 500 persons is being considered for review in DBT) and the same may be resolved while formulating the DSIR proposal.

6. As regards the initiative on IPR Programme, it was said that the budget outlay needs to be amended. The Chairman observed that patent infringement court cases, included in the outlay involve complex legalities and DSIR may stay away from them. It was stated that softwares have been developed by US based companies viz. MCAM (CEO-Mr. David E. Martin) and SAS which help companies in conducting patent searches affordably. It was suggested that DSIR may propose to acquire such softwares and make it available for use by the industry and institutions.

7. As regards the proposed women's programme, a written note received from the Ministry of Women and Child Development talks about drudgery reduction of women through use of technology. It states that the NRDC scheme on Promotion of Rural and Household Technologies can be used to demonstrate and exhibit modern technologies related to rain water harvesting, sprinkler based irrigation systems, herbal products etc. to improve the livelihood of womenfolk. Also, NRDC's rural technology demonstration cum training centers can be used to provide training to self help groups of women.

8. A written note received from CII recommended that DSIR should support at least 250 technology development projects in the 11th plan. Further, a bank of consultants in select areas may be developed who may be available to help industry in technology source identification, technology development process, technology transfer, commercialization and marketing.

9. On CEL, it was opined that up-scaling of production capacity of solar cells & modules to 25 MW may be inadequate in view of the rising demand for SPV products and systems. CMD, CEL stated that up-scaling beyond 25 MW would be much easier and would be taken up after completion of the present up-scaling from 2 MW to 25 MW.

10. On NRDC's new initiatives, it was said that NRDC must facilitate venture capital funding and even co-invest with VC funds to encourage technologists, entrepreneurs and professionals to take up risky ventures. The other initiative of NRDC to develop basic engineering design packages for technologies licensed to NRDC so as to attract entrepreneurs to take them up for further up-scaling was also supported by the working group.

Thus, the working group broadly agreed to the DSIR 11th plan proposals amounting to Rs. 1153 crore, given in Appendix 2.

The meeting ended with thanks to the Chair.

APPENDIX-1

LIST OF PARTICIPANTS

1. Dr. R.A. Mashelkar, Secretary, DSIR - Chairman

2. Shri Nirmal Singh, Department of Commerce
3. Shri Chandan Saha, DCSSI
4. Dr. A.K. Gopal, Director (NIPCCD), M/o of Women & Child Development
5. Dr. K.V. Raghavan, Chairman (RAC), DRDO
6. Dr. Amit Biswas, Reliance Industries Limited
7. Dr. M.D. Nair, Consultant to Pharma Industry
8. Dr. U.P. Phadke, DIT
9. Shri John Thomas, FICCI
10. Shri N.V. Sathyanarayana, Informatics India Limited
11. Dr. Lalit Kumar Das, I.D.D Centre, I.I.T Delhi
12. Dr. O.P.Agarwal, CSIR Emeritus Scientist, ICMR
13. Shri G.K. Moinudeen, CII
14. Smt. J. Khurana, DIT
15. Dr. A.S. Rao, DSIR
16. Shri R.R. Abhyankar, DSIR
17. Smt. S. Ravindran, DSIR
18. Smt. Jyoti S.A. Bhat, DSIR
19. Shri Subrata Banerjee, DSIR
20. Dr. S.K. Kulshrestha DSIR
21. Dr. K. Kamal, DSIR
22. Shri G.M. Bagai, DSIR
23. Shri Somenath Ghosh, CMD, NRDC
24. Shri Bimal Kumar, NRDC
25. Dr. S.K. Kaicker, CMD, CEL
26. Shri S.V. Subbarao, CDC

27. Shri Ashwani Gupta, DSIR - Member Secretary

APPENDIX-2

PROPOSED OUTLAY FOR DSIR 11TH PLAN PROPOSALS

Rs. in Crore

S.No	**Programme**	**11th Plan Outlay**
	TPDU (On-going)	
1	Industrial R&D Promotion Programme	2.5
2.	Technology Development and Innovation Programme Technology Development & Demonstration Programme Technopreneur Promotion Programme (TePP)	 60 30
3.	Int'l Technology Transfer Programme including APCTT	30 14
4.	Consultancy Promotion Programme	30
6.	Technology Management Programme	50
7.	Technology Information Facilitation Programme	29
8.	IT Activities	5
9.	Women's Programme	6.5
	TOTAL	**257**
	New Initiatives	
10.	SBIRI other than Bio-technology	500
11.	Fund for Accelerating Start-ups in Technology (FAST)	75
12.	IPR Programme	100
	Total	**932**
13.	**CEL**	**43**
14.	**NRDC**	**168**
15.	**CDC**	**10**
	Grand Total	**1153**