Central Leather Research Institute, (CLRI), Chennai is one of the constituent laboratories of the Council of Scientific & Industrial Research (CSIR) with a mandate for seeking excellence in leather science and technology. The laboratory has emerged as the global leader in leather research with global shares of 30% in peer reviewed publications, 7-10% in IPR products and 35% in human capacity built annually in leather. With a wide core competence encompassing biology, chemistry, engineering and leather science the institute has been able to gain peer recognition for valuable contributions made in R&D.

The institute is a model for Public-Private Partnership. The close association of CLRI and the industry serves as a role model for other manufacturing sectors. Over the past 59 years, the relationship between CLRI and the industry has only grown stronger and more vibrant. Transformation of the industry from a traditional to a technology driven manufacturing has been possible through CLRI providing need-based technology solutions. Outreach mechanisms of the institute have addressed the needs of all segments and sections of the leather and allied industries.

Research and Development programs of CLRI have been categorized into eleven areas. These eleven areas are a) Leather Processing Technology, b) Leather Product Technology, c) Environmental Technology, d) Leather Chemicals Technology, e) Center for Human and Organizational Resource Development, f) Core Groups in Basic Sciences, g) Engineering for Modernization & Safety, h) Center for Operation, Management and Policy for Leather Technology, i) Expertise Center for Eco-Testing, j) Skin Biology and k) Biomaterial Development and Testing.

CLRI has adopted and implemented unique management initiatives for ensuring smooth and effective organizational cohesion. Some of the initiatives include performance-based equipment grant allocations, incentive grant scheme for enhancing publications and patents, recognition of contributions of individual scientists through an award scheme and motivational exercises for all categories of staff.
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Institute Councils

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Acting Director  
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MANAGEMENT COUNCIL – July 2005 to June 2007

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Dr A Subbarama Naidu  
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Dr P T Perumal  
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Mr B Thangaraj  
Technical Officer

Mr B Selvakumar  
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Mr N K Chandrababu  
Scientist

Dr A Garg  
Scientist

Mr Manuel Thomas  
Controller of Administration

Mr Gautham Gopalakrishna  
Scientist

Dr (Ms) A Amudeswari  
Scientist
Space and time are the two most important and contributing parameters in reality and many effective management systems. CLRI has versatility and connectivity in academics, research and industries. Moreover, CLRI has secured a top place in the map of scientific development. The external cash flow (ECF) of this institute during 2000-01, 2001-02, 2002-03, 2003-04 and 2004-05 were 6.6, 6.5, 6.1, 8.1 and 9.5 crore rupees, respectively. However, a quantum jump in ECF (of Rs 13 crores) was obtained during 2005-06. During this period, my predecessor Dr T Ramasami was elevated to the post of Secretary, Department of Science and Technology, Government of India. In July 2006, I entered into this high level of R&D Leadership and effective management system. I had some fear about the financial sustainability of the institute. An honest attempt was made with the help of our colleagues and students. The stakeholders of the institute continued their support as well, and as an outcome of this, we have achieved an ECF of Rs 9.5 crores during 2006-07, through a unified goal and approach. The completion of the tenth plan and initiation of the eleventh plan had been conceived during this period. Although we have done well, we have the motto to execute the ensuing eleventh five year plan with the advent of a strong R&D achievement and high quality of science as well as keeping our minds in a “TEAM INDIA SPIRIT”.

Looking back at the realization of some of our dreams reported during the last year, the two lead and integrated outputs of network projects of CSIR, namely, Zero Emission Research Initiative Leadership (ZERIL) and Winning Water from Wastes for Leather (WWWL) have been commissioned and significant outcome in leather sector is foreseen. CLRI had made efforts to consolidate on leads gained by the institute for technology standardization of bioresources for and from leather and provided viable technology solutions for achieving Total Dissolved Solids (TDS) norm and management of solid wastes generated from the processing sector. Apart from TDS reduction through in-plant measures, chilling as a method of preservation, use of Neem and other bioresources for preservation, low salt preservation and enzymes as dehairing and fibre opening agents have paved a way in leather processing area. Installations of RO plants, performance evaluation of CETPs, Chemo autotrophic activated carbon oxidation and secured landfill facility for tanneries have been developed.

Global visibility of the research outputs has been gained through a total of eight collagen based biomaterial products, which have found clinical applications in burn management and wound healing. Newer chemicals and products have been synthesized, which have potential applications in leather industry. Core groups in basic sciences have addressed the important issues in science. The research outputs from these groups have found high acclaim amongst the peers in science, as seen from the high citation index for CLRI publications. Several of CLRI publications are amongst the top downloaded articles.

The Program Implementation Unit of Integrated Development of Leather Sector (IDLS) of the Ministry of Commerce & Industry, GoI functions from CLRI. The unit receives, screens and implements various modernization programs in Indian tanneries. Two major programs are being implemented by CLRI viz., Human Resource Development
Mission and Global Benchmarking Scheme. These are very important initiatives of the Government of India. HRD mission has targeted large masses, including 60,000 shoe makers in Agra. The Global benchmarking scheme enabled a total of 75 units in leather sector to benchmark against best global practices in terms of productivity and quality. It is noteworthy to mention that the program has provided for a >10% increase in production.

CLRI had planned to become the global leader in research relating to leather and allied industries. The visits of the Hon'ble South African High Commissioner, Shri Francis Moloi; Shri Festus Mogae, His Excellency The President of Botswana with his delegation and a delegation from Thailand paved way for exploring areas of mutual cooperation and forging partnership. A letter of intent was signed between CLRI and Department of Veterinary Services, Ministry of Live Stock and Fisheries Development, Nairobi for undertaking collaborative research and exchange of S&T personnel between the two organizations.

CLRI has been organically linked to two NMITLI programs. The “Biotechnology for Leather” and “Development of environmentally secure rare earth colorants for surface coating applications” programs have moved into the second phase, where some of our successful technological leads are moving to stages of pilot scale demonstration and commercial evaluation. Upscaling facility for production of enzymes is on the anvil.

LERIG 2007 focused on “Benign Environmental and Sustainable Technologies” (BEST). There was a good level of participation from the industry and other stake and shareholders of the institute. Several of the participants at the AT HOME function of LERIG 2007, which included the Secretary, DST and other leading dignitaries of trade and commerce, remarked that the “BEST” was truly the best.

The year 2006-07 had three successful MODEUROP roundtables, including the MODEUROP roundtable in INDIA during Jan/Feb 2007. The seasonal MODEUROP color cards were released along with the FOOTprint, FOOTHOLD and TOEHOLD magazines. 17 colors for shoes and 11 colors for garments were chosen from the colors presented from India in June 2006 and in January 2007, these were 17 and 9 respectively. Fellowships to various academies in India and abroad have been received by several scientists. CLRI also received the first ever CSIR Award for S&T Innovations for Rural Development in 2006. The CSIR Technology Prize for Business Development and Technology Marketing was also won by CLRI in 2006.

CLRI is an institution with a vision, it has a defined mission. Crossing intellectual frontiers based on global prior art and first to arrive principle, linking to national agenda through leather missions, redressing a national shortfall through leveraging technology and resource base, innovating for industrial leadership through demand driven technology elements with value for money as leadership dictum forms the vision for CLRI in the eleventh plan period. In taking us closer towards our Vision 2010, each and every single individual of CLRI has contributed. We step into the Diamond Jubilee of CLRI on a high note. Programs on nanotechnology for biotechnology, smart biomaterials for human care, atom economy in leather processing, eco-designs in leather products and smart products for and from leather are being initiated. The achievements of the past, the leadership through the years have kept us moving and inspired. CLRI has the wherewithal to march ahead, to set taller goals for ourselves, and meet them through a concerted effort. We are sure that the days to come will see CLRI emerging taller and taller.

Prof. Dr A B Mandal

April 2007
निदेशक प्रतिवेदन

अंतरिक्ष और समय, कई प्रभावशाली प्रवेणन प्रणालियों के संचालन और प्राचंतकों की, दो महत्वपूर्ण बातें विद्यमान हैं। केंद्रीय वर्ष अनुसंधान संस्थान में शिक्षण अनुसंधान और उद्योगों को आयात में एक साथ जोड़ने की सर्वश्रेष्ठ प्रतिवेदन है। केंद्रीय वर्ष अनुसंधान संस्थान ने वैज्ञानिक विकास के मान्यता में उन्नयन पर अनगीत परमाणु बना लिया है। इस संस्थान को वर्ष 2000-01, 2001-02, 2002-03, 2003-04, 2004-05 में बाहर नकद राशि क्रमशः 6.6, 6.5, 6.1.8.1 और 9.5 करोड़ रुपये थी। वर्ष 2005-06 में केंद्रीय वर्ष अनुसंधान संस्थान ने 13 करोड़ रुपये बाहर नकद राशि प्राप्त करके एक ज्ञात छोटा लाभ मिला। प्रतिवेदन के इस वर्ष में मेरे पूरवतिकारी, डॉ. गोविंद, रामनाथ, भारत सरकार के, विज्ञान और प्रौद्योगिकी किवास में सचिव के पद पर आसीन हुए हैं। अनुसंधान और विकास के इस उद्धर वर्कर और प्रभावशाली प्रवेणन के पदवी को मैंने एक मई, 2006 को प्राप्त किया है।

संस्थान के विश्वसनीय स्थिति को बिगाड़ बनाए रखने का मुख्य केंद्रवेश (ECF) के लक्ष्य के बाहर विद्यमान है। केंद्रीय वर्ष अनुसंधान संस्थान का संस्थान के संचालन पर उपचार करवाए गए उपाय जैसे कि विश्लेषण की शीघ्रता विधि, परिवर्तन के लिए उद्योगों में लाए जाने वाले "नॉम" और अन्य जैव संसाधन, कम नमक लगाकर परीक्षण विधि, खाली से भर उतारने की एनाइम विधि तथा फायदे खोलने की अभिकल्पित क्रमों का प्रभावित प्रक्रिया के क्षेत्र में प्रयोग होने की विधि का अधिकार चार उद्योगों को उन्नत संसाधनों को प्रौद्योगिकी के मानकीकरण के फलस्वरूप में चारों वर्षों के पूर्व क्रम से विद्यमान [Total Dissolved Solids (TDS)] होने के कार्य और चर्चाच्याताकरण में से चार प्रक्रिया के समय लिखे चारों पदवाओं के लिए मानक प्रबंध निर्देश दिए गए हैं। उद्देश्य परीक्षण पॉट संजोग के स्थापना, समायोजन बहस उपचार संस्थापन नियुक्तिरु वहाँ का मूलभूत कार्य, केंद्रीय स्वायत्तसंस्थान अधिकृत के स्वतंत्र होने और चर्चाच्याताकरण के लिए भूमिका दृष्टि का विकास, एकथल्लिक और वाणिज्यकरण किया गया है।

कोलेज आधिकारिक आठ जैव-पदवाओं में से दो कोलेज आधिकारिक जैव-पदवाओं उद्योग का उपयोग क्लीनिकल स्कैन मर तथा लाभ प्राप्त करके उद्योग के भविष्यवाणी ने लाए जा रहा है। इस अनुसंधान कार्य को विश्व संग्रह से हरा रखा जा रहा है। चार उद्योग हेतु ए रासायनिक उद्योगों के उपयोग की संबंधितों को खोज की जा रही है। मूल विज्ञान के मूल समूह में विज्ञान के महत्वपूर्ण चारों के लिए उद्योगों विषय पर कार्य किया जा रहा है। इस निळी समूहों के अनुसंधान पर्यावरण को अन्तर्दर्शन में सराहना की गई है; केंद्रीय वर्ष अनुसंधान संस्थान के कला लेखों के संस्थान की वेबसाइट से डाउनलोड किया जाता है।

भारत सरकार, उद्योग मंत्री, चार विकास एकाधिक ओला क्रियाव्रत कार्यक्रम एक, केंद्रीय वर्ष अनुसंधान संस्थान परिसंहार से हो संगठित किया जा रहा है। यह एक बहुभाषी प्रयोगशालाओं के आधुनिकीकरण करने संबंधित कार्य के पश्चात करके, छात्रावाद करने के बाद, अविकल कार्यवाही करता है। केंद्रीय वर्ष अनुसंधान संस्थान द्वारा, मानव संसाधन विकास मिशन (HRDM) और मिशन बेंचमार्किंग स्वॉम (GBS), दो मुख्य कार्यक्रमों का नेतृत्व किया जा रहा है। ये दोनों कार्यक्रम भारत सरकार की एक महत्वपूर्ण शुरुआत हैं। मानव संसाधन विकास कार्यक्रम के अंतर्गत एक बड़े जनसमूह को लक्ष्य बना कर एक कार्यक्रम आरंभ किया गया, जिसमें आगारा के 60,000 जुला-
During the year, the leather processing group had made focused efforts to address the Total Dissolved Solids (TDS) issue through technology initiatives. Some of the technologies developed for reducing TDS in tannery effluent include in-plant measures for reduction of TDS, short term preservation methodologies such as chilling and low salt preservation techniques.

**TDS reduction through in-plant measures**

Two tanning clusters in Tamil Nadu were directed by the Tamil Nadu Pollution Control Board (TNPCB) to reduce the TDS in the treated wastewater. After having studied the process schemes and the emission pattern in the tanneries of these two clusters, suitable in-plant TDS reduction measures were identified, implemented and standardised. This has led to reduction in TDS to less than 7,000 mg/l.

**Chilling as a method of preservation**

Fundamental microbiological and engineering aspects of chilling system as a method of preservation of hides/skins have been studied and process conditions standardised. A mobile chiller has been designed and field tested. Trials at semi commercial / commercial scale have been conducted. The overall cost-benefit that this system offers to salt curing has been analysed and this is considered a viable option.

**Low salt preservation**

For preserving the skins for a significant span of time, low salt based system has been tried and standardised. Common salt as low as 5% was used along with MgO and the cured skins could be preserved for a period not less than 40 days. The quality of leathers were on par with those made from conventional salt curing. Commercial scale trials have been conducted.

**Lime and sulfide free dehairing**

A new bacterial strain producing protease has been isolated and the protease tested for its efficacy in dehairing application. Preliminary experiments indicate that the enzyme has good dehairing efficacy.
Shoe Design & Development

The Shoe Design & Development Centre continued its efforts in the area of newer materials and product innovations in footwear, biomechanics, fashion forecasting and training.

A novel approach for sole bonding technique in full shoe manufacture using microwave heat activation

Bonding process in shoes generally takes place after the adhesive is activated with IR radiation followed by pressing and curing. Many a time, if temperature and time are not controlled properly, it leads to either weak bonding or material disintegration. To overcome this problem an alternative heat activation technique using domestic microwave oven was tried at different energy (wattage) levels and time duration of activation. Study was conducted with commonly used upper and soling materials at various energy levels and times of activation of 10 seconds and 20 seconds. Microwave heat activation as a method for sole bonding has been found to be effective at 20 seconds heat activation time.

Development and utilization of new materials for therapeutic footwear applications

Many viscoelastic materials are used in shoes to replace the shock-absorbing and pressure distributing functions of natural fat pad beneath the foot that was lost due to conditions such as diabetes, arthritis, age or overuse. Segmented polyether polyurethanes were synthesized and developed into sheets by blending with commercially available polyester polyurethane. The cushioning and morphological properties of developed materials were studied for application in therapeutic footwear.

Integrated software for prescription of footwear design based on computational risk category estimation has been developed for diabetic patients.
Design and Trend forecasting

A total of 17 out of 20 colours for Shoes & 10 out of 11 colours for garments feature from India for the Autumn/Winter 2007-08 season as predicted by MODEUROP. Fashion intelligence has been disseminated through Foot Prints, Foot hold, Trend Forecast, Bag Picture and Revisit.

India design outreach

CLRI in association with Council for Leather Exports (CLE), set up a ‘Theme Pavilion’ at the Expo Riva Schuh Fair at Garda, Italy to showcase India’s rich heritage in leather & finished products and highlight Destination India to all the visitors.

Leather Apparel and Accessories Design & Development

Leather apparel and accessories group has worked extensively on materials, methods & applications and developed unique combination products with leather. Since emerging trends offer immense opportunities for combination products, exclusive products from natural materials such as pineapple fibre have been designed and developed as fashion accessories.

Online course has been developed for leather goods manufacture. A package for on-line status tracking system for enabling the buyers and leather product manufacturers has been developed. Many of the apparel design packages support only specific proprietary output devices (plotters/cutters). To solve this incompatibility a customised utility software has been developed to convert cutter and plotter device files to commercially available plotters & pattern cutters.

A suitable novel natural fabric made out of pineapple leaf fibre (PALF) has been identified for combination with leather to fabricate a range of products. The South Indian Textile Research Association (SITRA) has successfully produced yarns from 100% PALF. The yarns are loomed into fabrics. PALF has been combined with leather and a range of products have been developed.

As a luxury fibre, cashmere commands high price. Cashmere though weaker than wool is a soft and resilient fibre that is receptive to dyes. The knitwear industry is the largest consumer of cashmere. However, significant amounts of cashmere go into accessories, rugs and cloth for luxury coats, jackets and suits for the menswear. Combination of cashmere fabrics with leather has led to a range of products.
Environment research group has continued to address the environmental issues of the leather processing sector. Efforts aimed at providing technology solutions for solid waste management, waste treatment, removal of organics from water and methods for effective Common Effluent Treatment Plant (CETP) Operation and Maintenance (O & M).

**Membrane reactor**

Total Dissolved Solids (TDS) in tannery effluent being a cause of serious environmental concern, Common Effluent Treatment Plants (CETPs) and Effluent Treatment Plants (ETPs) recover and reuse the water through Reverse Osmosis (RO) plants. To increase the life of the RO membrane, pretreatment of the waste water using sand filter, photochemical oxidizer, activated carbon filter, cartridge filter, dosing systems is essential. A membrane reactor combining conventional biological treatment processes with membrane filtration has been developed for organic and suspended solids removal. Membrane reactor eliminates the use of sand and cartridge filters.

**Performance evaluation of CETP**

Two CETPs were selected for evaluation and assessment. Data on chemical and electrical consumption, O & M expenditure and the respective rate of inflow of wastewater were collected. The cost of chemical consumption to remove Total Suspended Solids (TSS) was calculated. Studies aimed at optimization of process parameters for maximizing removal of suspended solids. The results were compared with actual performance, in order to recommend appropriate control measures for minimizing chemical consumption and O & M cost. The maximum demand, apparent power, reactive power and power factor, of each machinery attached to each unit operation of the treatment was evaluated to calculate the cost of power consumption per kg of TSS, Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) removed. Based on the information collected on the equipment, hours of operation and efficiency of the process, cost control strategies were recommended.
Chemo autotrophic activated carbon oxidation

Chemo Autotrophic Activated Carbon Oxidation (CAACO) is a mixture of biological and chemical oxidations in a single, chemoautotroph immobilized activated carbon, packed bed reactor. Oxygen required for the oxidation of organics is applied in the form of compressed air from the bottom of the reactor. The wastewater to be treated is applied across the cross section. The oxidation of organics in wastewater occurs while the fluid streams (air and wastewater) flow in the counter current direction. The treated wastewater is collected from the bottom of the reactor. Biodegradation of organics in CAACO reactor is accomplished with minimal energy input and without sludge production. CAACO technology has features such as low foot print, low energy input, zero secondary sludge production and zero emission of green house gases. CAACO based treatment systems have been implemented for the treatment of wastewater discharged from leather, textile, chemical, pharmaceutical and food industries in India for volume of wastewater ranging from 50m$^3$/day to 2000m$^3$/day.

Secured Landfill Facility (SLF) for tanneries

CLRI has designed and developed a decentralized secure landfill system for sludge generated from tannery sector with Reinforced Cement Concrete (RCC) structure with provision to collect leachate and treat in CETPs and also to accommodate more quantity of sludge with less area. This decentralized secure landfill system has been implemented in a major cluster in Tamil Nadu with financial assistance from Ministry of Commerce and Industry.
R & D initiatives aimed at development of chemicals and formulations which have potentials for application in leather.

**Enzymes as dehairing agents**

Bovine pancreatic enzyme was found to depilate the hairs on skins and hides. This finding leads to the development of a process for lime-sulphide free dehairing in leather processing.

**Synthesis of Polydimethylsiloxane (PDMS) - Imide membranes**

Siloxane materials provide advantages such as low temperature flexibility, high thermal stability, hydrophobicity, oxidative resistance, biocompatibility and significant gas permeability. Polyimides exhibit thermal stability, dimensional stability and electric property and find application in aerospace and electronic industries. However, polyimides are generally insoluble and infusible, unless carefully tailored to improve the solubility of these materials in wide range of polar and non-polar solvents. Polyimides with polysiloxane groups as side chains were synthesized to enhance thermal properties. A series of novel poly(imide-siloxane)s (PIS) were synthesized by the grafting of amine terminated soluble imides to the siloxane backbone. The polymers were characterized by FT-IR, $^1$H and $^{13}$C NMR. The polymers were found to be stable up to a temperature of 350°C.

**Design, synthesis and structural modification of benzothiazole moieties for biological applications**

Benzothiazole moiety is a pharmacologically significant organic entity with application as antitumor agent. Thiazolidinone derivatives possess antimicrobial, antiviral and anticancer properties. The biological activities of these benzothiazole and thiazolidinone moieties are expected to be due to the presence of heterocyclic systems containing nitrogen and sulphur atoms. A novel and efficient method has been developed to synthesize a single molecule containing both benzothiazole and thiazolidinone moieties with a view to increase the potency of the biological activity by increasing the number of sulfur and nitrogen atoms through the cyclization of imine using Lewis acid as a catalyst.
Design and interfacial organisation characteristics of water soluble copolymers with comb like structures

The new monomer, Cholesterol Acrylamide Butyrate (CAB) with cholesterol chain and consisting of a spacer group of n-amino butyric acid has been demonstrated to promote copolymerisation reaction with acryl amido propane sulfonic acid (AMPS), to provide copolymers with cholesterol mesogen component as high as 15 mole%. The copolymers exhibit significant solubility in water at 0.5% (weight %) over wide range of pH and resistance to neutralisation. The density of non polar micro domains of copolymer solutions increases with cholesterol component as established from fluoroprobe method. Cholesterol side chain performs as a cross linking agent promoting intra or intermolecular aggregated structures as established from fluorescence quenching experiments.

Novel nanoparticle dispersion of a copolymer as chrome exhaust aid

The novel nanoparticle dispersion (NPD) of a high molecular weight copolymer ($6.04 \times 10^5$ daltons) in aqueous medium was investigated for its application as chrome exhaust aid. The copolymer chain is made up of two types of monomers, viz. an acrylic ester and an amino acid derivative. It has been demonstrated that NPD could perform as a high exhaust chrome aid to provide 94% exhaustion of chromium when used during chrome tanning operation.

Design and interfacial adsorption characteristics of a new surfactant

The dodecyl ester of l-tyrosine (LET) consisting of amino group in the protonated form has been designed. The solution of LET exhibits typical UV visible absorption characteristics showing $\lambda_{max}$ at 274 nm, due to aromatic group in its structure, similar to tyrosine. Scanning electron microscope shows that LET forms fibre like network structures with the width of $3.33 \pm 0.1 \mu m$. The novel features of LET suggest that LET could be used in generation of novel emulsion phase structures with scope for chemical modifications involving phenyl ring and the amino group.

Synthesis of heterocyclic compounds by novel routes

2-amino-chromenes are widely employed as pigments, cosmetics, potential agrochemicals and represent an important class of chemical entities being the main constituents of many natural products. Fused chromenes exhibit wide spectrum of biological applications as antimicrobial,
antiviral, mutagenic, antiproliferative and antitumor agents. An eco-friendly route to the synthesis of 2-amino chromenes and indolyl chromenes has been elucidated.

The indole moiety is probably the most common and important feature, of a variety of natural products and medicinal agents with significant biological activities including antimicrobial, antiviral and antitumor properities.

**Ceric sulfate catalyzed synthesis of 14-aryl or alkyl-14h-dibenzo[a, j]xanthene under conventional heating and microwave irradiation**

In recent years, attention has been focused on the synthesis of aryl-14H-dibenzo[a, j] xanthenes, due to their significant biological activities, as antibacterial, antiviral and anti-inflammatory agents. Xanthenes based compounds have been investigated for agricultural bactericide activity and some other benzoxanthenes find applications in industries such as dyes in laser technology and fluorescent materials for visualization of biomolecules. Ceric sulfate catalyzed synthesis of 14-aryl or alkyl-14H-dibenzo[a, j]xanthene under conventional heating and microwave irradiation has been carried out.

**Synthesis of acetamido phenols**

Compounds bearing 1,3 amino-oxygenated functional motifs are ubiquitous to a variety of biologically important natural products and potent drugs, including a number of nucleoside antibiotics and protease inhibitors, such as ritonavir and lipinavir. A facile method for the construction of 1,3-amido alcohols, has been developed as these molecules are versatile precursors for 1,3-amino alcohols and ligands for asymmetric catalysts.
Core Groups in Basic Sciences
Basic research aimed at investigations on three step tanning methodology, coupled water in biomolecules, synthesis and characterization of polymers and organic compounds with potential applications in leather and other industries.

**Leather Sciences**

**Towards zero discharge concept in leather processing**

A three step tanning methodology has been developed by CLRI towards a near zero wastewater discharge leather processing. Cow hides were dehaired using enzyme based dehairing method employing standard enzymes. Sides were treated with $\alpha$-amylase and water for 3 h in a drum. Alternatively, the sides were treated with sodium hydroxide and water in a drum; duration of treatment was one day. A pickle basification free chrome tanning at pH 5.0 has been developed with and without masking. The pH of the pelts was adjusted to 5.0 using three different acids namely sulfuric, acetic and oxalic acid without sodium chloride. Speciation studies were carried out during the course of tanning in order to understand the mechanistic pathways associated in the novel processing method.

**Chemical Sciences**

**Coupled water in biomolecules**

Quartz crystal microbalance (QCM) has been redesigned to evaluate hydro dynamically coupled water in small compounds and macromolecules. The free to bound water ratio in macromolecules, specially peptides and proteins have been analyzed implicating specific supramolecular organized structures. This has lead to the development of an experimentally designed hydropathy scale which compares very well with the earlier scales based on statistical analysis of protein structures. Spreading and adsorption of the peptides and proteins on solid substrates has been studied. The experimental results together with theoretical simulations have provided insight into the best solvent mixtures for optimal adhesion of surface coatings and also a method to test compatibility of components in blends used in coatings.
Aqueous solvent for Michael addition of indoles

A simple and environmentally friendly protocol for the Michael addition of indoles using water as solvent has been developed. This protocol eliminates the use of hazardous organic solvents and is operationally simple since the product can be easily isolated by a simple phase separation.

Design of three ring core mesogens

Three ring containing mesogens with terminal dimethylamino group linked by ester and azomethine units at the core have been synthesized. Another series of three ring containing mesogens were prepared using three ring mesogenic precursors consisting of terminal aldehyde functionality. Three ring mesogen series were prepared containing Schiff base. Schiff base mesogens were modified with terminal hydroxyl ends for use as mesogenic diols. Four ring core mesogens were synthesized with similar linking units. Two thiophene based mesogens were also designed. All molecules showed enantiotropic nematic phase with varying phase stability and have been extensively characterized.

Photo-Fries rearrangement of naphthalene-1, 5-Diyl bis (4-Chlorobutanoate)

Naphthalene-1,5-diol, available commercially at a low cost, has a symmetrical structure with placement of hydroxyl groups at 1 and 5 positions of naphthalene providing a two-fold rotational axis of symmetry. This diol could be easily converted into its bis-ester, namely, naphthalene-1,5-diyl bis(4-chlorobutanoate) 1, using 4-chlorobutyryl chloride under basic conditions. Tandem Fries-Friedel-Crafts reactions could be achieved under thermal conditions with Lewis acids such as AlCl₃ or Sc(OTf)₃.

DNA cleavage properties of metal complexes

Influence of ligand structure on the DNA binding and cleaving property of metal complexes has been investigated. Complexes of terpyridyl derivatives with variety of metal ions have been synthesized and crystallographically characterized. Copper (II) complexes of these ligands show nuclease activity in the presence of a co reagent like hydrogen peroxide or ascorbic acid. On the other hand Cobalt (III) complexes of these ligands cleave DNA photolytically due to their high excited state potential.

Organization and assemblies of peptides-surfactants

The aggregation properties of Tyr-Phe dipeptide and Val-Tyr-Val tripeptide were studied in aqueous solution and in the presence of Sodium Dodecyl Sulfate (SDS) and SDS-polymer
environments using UV visible, surface tension, fluorescence and circular dichroism (CD) techniques. Effect of peptides on the aggregation properties of SDS also was investigated. SDS is more stable in micellized form in the SDS-water-peptide ternary systems compared to corresponding SDS-water binary systems. Two-dimensional surface properties of Poly ethylene oxide (PEO)-Poly propylene oxide (PPO)-PEO triblock copolymer film (Mol. Wt. 2800) in the absence and presence of Tyr-Phe dipeptide, Val-Tyr-Val tripeptide, sodium dodecyl sulfate and stearic acid have also been investigated at the air/water interface using Langmuir film balance technique.

**Removal of SAMs**
Organized self-assembled monolayers (SAMs) of thiol on the metal surfaces are formed easily by soaking the substrates in thiol solution for few hours. These layers are stable since there is chemical bond formation between the substrate atom and the sulfur atom of the thiol and also the hydrophobic interactions of alkyl chains. A detailed study on the removal of SAMs by surfactants has been carried out. CV studies were carried out to elucidate the blocking properties of SAMs of thiol and also to investigate the stability of the thiol with respect to (i) electrode potential (ii) CTAB. CV experiments were carried out in the following potential ranges: -0.4 to +0.4 V (b) -0.2 to +0.9 V (c) -0.2 to 1.6 V in 0.5 M sulfuric acid.

**Atomic and molecular clusters: Hydrogen bonded molecular assemblies**
Hydrogen bonding has unique strength character ranging from few kcal/mol to 40 kcal/mol and directionality. It has been observed that the electron density at the hydrogen bond critical point increases linearly with increasing stabilization energy from weak hydrogen bonds to moderate and strong hydrogen bonds, serving as an indicator of the nature and a unified picture of Van der Waals to classical H-bonding to strong H-bonding. New nano materials have been designed based on the H-bonding interaction. It has been shown that the linear water clusters exist in their own right.
Biological Sciences

Wound healing in diabetes
The study on the causes leading to delayed wound healing in diabetic foot ulcers showed high lipid peroxidation indicative of oxidative stress in the neuro ischaemic foot ulcer infective group. The level of cytokines IL-6 and IL-8 was upregulated in the neuropathic and neuroischaemic foot ulcer – infective groups. The proteolytic enzymes responsible for the degradation of extra cellular matrix (ECM) components during tissue remodeling are matrix metalloproteinases.

Composite scaffolds as biomaterials
Studies to understand the structural and functional aspects of the 3D Scaffold for cardiomyocyte culture is being conducted at Sri Ramachandra Medical College (SRMC) and CLRI. Normal heart tissue was decellularized and viewed using a Scanning Electron Microscope (SEM). The image of the Right Atrial Appendage (RAA) after decellularization revealed criss crossing trabecular architecture resembling a honey comb with cavities varying in size.

Chromium induced biotoxicity
Investigations have been carried out to understand the biotoxicity of Cr on lymphocytes. Some of the signaling molecules which take part in the biotoxicity process have been identified and the sequence of activation arrived at using inhibitors for these signaling molecules. A signaling pathway has been elucidated for Cr induced apoptosis of lymphocytes. Reactive Oxygen Species (ROS) is an early event and activates down stream effectors such as Src family tyrosine kinases and caspase 3. Studies revealed zinc protects lymphocytes from Cr(III) induced apoptosis. The $^{35}$S-cysteine labeling studies have indicated that in the presence of zinc, Metallothionein (MT) synthesis is induced in lymphocytes.
Collagen based biomaterials have found extensive applications in health care systems. Process for preparation of soluble collagen and reconstituted collagen sheet has been standardized from calfskin and amniotic membrane. These scaffolds were used as such or in combinations to develop novel wound dressing materials. *Aloe vera* – collagen based membrane has been developed as an active composite biomaterial, which elicited positive healing of burn wounds and acted as substrate for culture of human dermal fibroblast.

Collagen scaffolds were designed as controlled drug delivery systems in a wide variety of wounds with emphasis on mitigating infection and modulation of Matrix Metalloproteinase activity (MMP) activity to hasten healing. Effectiveness of Sodium Dodecyl Sulfate (SDS) loaded alginate Microsphere Impregnated Collagen Scaffold (SSDM-CS) System was assessed through infection (*Pseudomonas aeruginosa*) in deep second-degree burn wounds in rat model. SSDM-CS was able to hasten the healing process at a much faster rate.

Dermal, epidermal and full skin equivalents have been developed indigenously for clinical application using collagen and collagen-chitosan composites. All these equivalents were of 2-D nature. The 3-D tissue engineered construct was developed by adding the known number of fibroblast cell suspension in collagen solution and cast as gels. It is used as a dermal equivalent and a model for evaluation of active constituents *in vitro.*
Investigations for understanding the biochemical and molecular mechanisms of abnormal wound healing have been carried out. In the dermis of keloids more activated MAP kinase expression was seen whereas in hypertrophic scars, epidermis showed increased expression. Decorin levels in abnormal wounds have been studied. Interestingly RT-PCR analysis of dermal fibroblasts of keloids showed low expression of decorin compared to hypertrophic scars and normal skin. Expression of decorin has been evaluated using anti decorin antibodies in mice. It is hypothesized that the up-regulation of MAP kinase activity and low levels of decorin may be the contributory factors for excess collagen deposition and its abnormal assembly in keloids. Based on the observations, the cDNA encoding decorin was prepared, sequenced, and cloned into the pGEMT- PCR cloning vector. The cDNA encoding decorin was excised from the PCR vector and subcloned into the bacterial expression vector for the preparation and purification of recombinant decorin. This recombinant used along with collagen as dressing material has been tested for its efficacy in vivo.
The chemical engineering group has been providing engineering inputs for the leather industry for preparation of techno economic feasibility reports and design engineering packages for establishment of complexes. The basic research activities of the group have aimed at providing insights into the understanding of scale up and process engineering.

**Standardization of control & processing systems for modern leather processing**

Process control systems for chemicals and water addition and pH control have been designed, developed and implemented in a number of tanneries in the country. In association with the tannery group in CLRI a device for odor control has been designed and developed and is ready for field trials.

Power ultra sound studies indicate potential applications in leather processing.

**Drying of leather & effluent treatment**

Different drying techniques like radio frequency drying and vacuum drying have been tried for the drying of leather for better productivity and physical properties. Methods for chemical and biodegradation of dyes in the tannery effluent streams have been developed.

**Thermochemical analysis & Bio calorimetry**

A valuable and systematic protocol for the experimental identification of runway potentials of reaction systems has been developed. Properties of firework chemical compositions have been studied to assess risk free preparations.

Bio calorimeter studies aim at investigating the metabolic reaction of microorganisms in tannery saline effluent.
Centre for Human & Organizational Resource Development (CHORD)
Centre for Human & Organizational Resource Development (CHORD) organizes several education and training programmes to a varied learner target by conducting various academic, vocational and specialized long and short-term training programmes in leather and leather products working in tandem with Academic Institutions/Leather Industry/National Centers of Excellence.

**Academic programmes**

The cumulative strength of B.Tech leather technology course over the past ten years has reached 400. Placement record for students has revealed that 100% of the students find placement. 44 B.Tech and 12 M.Tech Leather Technology and Footwear Science & Engineering students had received their degrees.

**Vocational training**

Total of 58 candidates had completed the vocational training programmes.

261 candidates from the leather industry and various organizations have undergone training in various fields of leather and leather products technology.

**International training programmes**

11 international candidates from Sudan, Ethiopia, Kenya and Iran received training in leather and leather products technology.
Centre for Operation, Management and Policy in Leather Technology (COMPLETE)

Centre for Operation, Management and Policy in Leather Technology (COMPLETE) includes business process development strategies, technology planning and monitoring, economic research initiatives and development of tools and techniques in information technology.

R & D planning

Programme planning and monitoring involved implementation of review mechanisms for Network and New Millennium Indian Technology Leadership Initiative (NMITLI) programmes of CSIR. Strong linkages and partnerships have been established with business houses and R&D institutions for unique basic research activities and for translation of R & D leads into commercially viable products. Sectoral Report on Leather has been prepared in consultation with stakeholders. The Sectoral Committee has recommended launching of a India Leather programme aimed at gaining 7bn USD exports in the next five years by development of strategies for maximizing resources, technology and market initiatives.

Business process development

Activities included enlarging clientele base, increase in IP portfolio, technology transfer and licensing to identified and interested users, rigorous review of grant-in-aid, consultancy and sponsored research projects, customer evaluation and satisfaction and wide information dissemination on CLRI’s knowledge base in Fairs/Seminars/Exhibitions.

Customer satisfaction and evaluation studies were conducted. The Customer Satisfaction Index (CSI) for CLRI is 4.4 on a 5 point scale.

Technology led entrepreneurship programme was organized at CLRI in association with HRDG, CSIR and IRM, Bangalore during February 12 – March 11, 2007. 67 research students from various CSIR Labs, Anna University and Madras University participated in the programme.

Enterprise Resource Planning

Enterprise Resource Planning is under implementation at the institute by CMC. Total of nine modules have been designed and developed for smooth execution of routine activities.
Specialized Expert Systems
The Expertise Centre for Ecotesting (EXCEL) laboratory of the institute provides services to the industry for assessment of chemicals and other components for the leather industry. As a part of the efforts being made to develop improved analytical techniques and methodologies, research investigations have been carried out.

Cell for Industrial Safety and Risk Analysis (CISRA) undertakes consultancy projects for the chemical industries. CISRA has been striving to improve the models used in fire explosion and dispersion. A database on accidents to supplement the studies in the area of industrial risk and safety has been developed.

The concept of control banding has been recognized globally. This basically aims to assess the risks and identify appropriate controls for protection of the workers. In order to overcome the limitations of tool kits developed earlier a tool kit has been developed for estimating the level of chemical exposure among workers.
CLRI under the Network programme of CSIR, had made efforts to a) consolidate on leads gained by the institute for technology standardization of bioresources for and from leather and b) provide viable technology solutions for achieving Total Dissolved Solids (TDS) norm and management of wastes generated from the processing sector.

**Zero discharge process system**

A process scheme and a range of options have been developed for zero wastewater discharge process from raw to tanning. Through the various recycling and reuse options developed and standardised, it is possible to reduce the water input from about 22 l/kg of skin to about 5.5 l/kg of skin. There is no wastewater discharge from the process system. An engineering package for this process scheme has also been designed. A pilot plant has been established for carrying out further research for zero discharge using various raw materials and products. The pilot plant is available to tanners for trying zero discharge process prior to standardising the same at commercial scale.

**Enzyme assisted dehairing and solid waste management**

The network project on bioresources has led to the development of a viable network of four CSIR laboratories to work on programmes of national importance on leather. Enzymes (proteases) for dehairing applications have been developed. Nearly 50% of the bioresources available from skin or hide have been sub optimally used. This causes solid waste disposal problem. Utilization strategies have been developed for solid wastes. Some of the products developed from fleshing by CLRI are high value animal feed (dog biscuits, chicken feed).

**Collagen based biomaterial**

A total of eight collagen based biomaterial products, which have clinical application in burn management and wound healing have been developed. Three of the collagen products viz. collagen sheet, reconstituted collagen sheet and collagen sponge have already been commercialized and have entered clinical use.
New Millennium Indian Technology Leadership Initiative (NMITLI)
The NMITLI programme on “Biotechnology for leather” in the first phase aimed at paradigm shift in processing of leather from chemical to bioprocessing. Extensive R & D by 12 research institutions has led to development of 18 product leads which offer technology options for salt less preservation, lime and sulfide free dehairing and fibre opening. Efforts are being made to convert the leads into commercialisable products through technology partnerships with chemical companies.

A turnkey contractor for operation and management of the upscaling facility for production of enzymes has been identified.

A dedicated team from CLRI has been formed for ensuring smooth execution and operation of the upscaling facility.
Under the Tenth Plan initiatives of leather sector of the Ministry of Industry, Government of India, two major programmes are being implemented by CLRI. These are Human Resource Development Mission and Global Benchmarking Scheme.

**Human Resource Development (HRD) mission**

The Mission mode programme aimed at addressing the training needs of both the decentralized production base and the organized sector. About 1.6 lakh people have been connected through unique HRD initiatives for skill mapping and upgradation, training of trainers, on site training for shop floor personnel, designer and supervisory level training activities, cluster development programmes for artisanal skill upgradation and management training programmes.

A major intervention in Agra footwear cluster has been implemented targeting 60,000 shoemakers in the region. A more structured training programme for generation of skilled work force for the industry in the region is planned as Phase II of the programme.

**Global benchmarking scheme**

The Scheme aims to enable total of 75 units in leather sector to benchmark against best global practices in terms of productivity and quality. 65 units have been enrolled. Productivity increase of >10% on account of interventions made has been reported.

**Footwear sector**

Recognizing the need for strengthening the non leather footwear production in the country, efforts have been made with support from the Ministry of Industry, Government of India, to establish training-cum-production centres in Kerala and North East. A proposal for establishment of non leather footwear training-cum-production centre at Jalandhar is under consideration.

**Management initiatives for the industry**

Institute for Financial Management & Research (IFMR) and CLRI developed management training programmes for senior level mangers and CEO’s of the industry. CEO Forum was held on 8-9th September and 20th December 2006. Topics for discussion included scalability and growth issues, instruments of finance, brand building, supply chain management and retailing. Eminent speakers were Dr T Ramasami, Secretary, DST, Shri MV Subbiah, Advisor, Murugappa Group, Prof M B Athreya, Athreya Management Systems, Dr R Kannan, Director, IFMR, Smt Mythili Chandrasekaran, VP, JWT, Shri PK Mohapatra President & CE, RPG Enterprises. Management programmes for senior level managers was organized at CLRI in association with IFMR.
Extension Activities
The Regional Centres of CLRI at Ahmedabad, Jalandhar, Kanpur and Kolkata continue to disseminate information on the technologies developed by CLRI and offer testing, training and consultancy services to the industry in the region.

**Regional Centre for Extension and Development (RCED), Ahmedabad**

Under the HRD Mission programme, 345 artisans from Kheda, Gandhinagar, Jamnagar, Bhavnagar, Amreli, Sabarkantha, Dahos, Porbandar, Bhuj districts were trained in better methods of leather and product making. 30 women from Alwar and Jaisalmer districts have been provided training in leather goods and leather toys making. Testing and evaluation studies for chemical companies were conducted.

**Regional Centre for Extension and Development (RCED), Jalandhar**

RCED, Jalandhar continued its support to the National Institute of Technology for conducting B Tech leather technology course. 12 persons were trained for three months in manufacture of soft protective goods (batting glove) for the sports goods industry, three in leather processing (one year diploma). The centre continued to provide modular training programmes in leather products manufacture. The Centre continues to offer technical services for the industry in the region.

Women centered training programme was conducted in Gurdaspur district for training 382 women in football stitching. Five training programmes, of two months duration each, in football stitching at Gurdaspur district under HRD Mission of DIPP, Government of India was conducted. The programmes were conducted at Gurdaspur, Dorangla, Bamiyal, Fatehpur village (Narot Jaimal Singh block) and Kalanpur block of Gurdaspur district.

**Regional Centre for Extension and Development (RCED), Kanpur**

RCED, Kanpur continued its technical and analytical services for the industry in the region. The centre has supported activities under the HRD Mission and the Tannery Modernization Scheme of the Government of India through enrolment of industry and target groups.

**Regional Centre for Extension and Development (RCED), Kolkata**

RCED, Kolkata continued its support to the eastern region for testing, consultancy services and training programmes.

A major programme has been launched with support from the HRD Mission of the Government of India for skill upgradation of the work force in the leather goods sector.
# Budget

### A. Recurring (Rs. in Lakhs)

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<td>HRD</td>
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<td>Maintenance</td>
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### B. Capital

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### Extra Budgetary Resources (Rs. in Lakhs)

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### % Contribution from Pvt. Sector

- 39%

### EBR as % Revenue Expenditure

- 553.58

### Staff Position as on 31.3.2007

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CLRI Patents filed/granted in India/Abroad during 2006-2007

A. Filed in India

1. An improved process for producing leathers in more than one tone.
2. A process for the preparation of bio-erodible insert for ophthalmic applications.
3. A novel scouring device for industrial applications.
5. An improved process for dehairing and fibre opening of hide/skin.
6. A novel ketene oligomer from aliphatic non-polar amino acids for industrial applications.
7. A novel alkaline protease and a process for the production thereof.
8. A novel transportable device for lifting and flaying of animals.

B. Filed abroad (Total applications - 12)

1. A novel dehairing and fibre opening process for complete elimination of lime and sodium sulphide (Brazil, Indonesia, China, Europe, Australia).
2. A novel transposed process for making leather (Australia, Indonesia, Brazil, Korea, Europe, China).
3. A novel protease for industrial applications (Germany).

C. Granted in India

3. An improved process for the preparation of composites such as particle boards/laminates (197338 11/8/2006).
5. A process for the preparation of novel bone implant and the bone implant produced thereby (199838 06/10/2006).
8. A process for the preparation of a biopolymer scaffold for medical applications (199822 05.01.2007).

D. Granted Abroad
1. Transposed process for making leather
2. Process for the preparation of aldehyde from a proteinous source for industrial applications
3. Process for the preparation of a formaldehyde-free synthetic tanning agent
4. Process for making chrome tanned leathers
5. An improved process for the preparation of bio-diesel
6. A novel process for the preparation of aldehyde from a proteinous source for industrial applications
7. A process for simultaneous recovery of chromium and iron from chromite ore processing residue
8. Process for the preparation of alkaline protease
10. Process for preparing a synthetic Aluminium tanning agent Patent No. AU2002348767; Date of grant - March 08, 2007

E. Copyrights filed for Software
1. INNOEST, Innovative Footwear Norms Estimator

F. Technologies Commercialized

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<td>M/s Dindigul Proteins and Feeds</td>
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<td>Waste water treatment</td>
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<td>M/s Enhanced Wapp Systems (India) Pvt Ltd, New Delhi</td>
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<td>Treatment of waste water</td>
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<td>M/s UPL Environmental Engineers Limited, Vadodara</td>
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Publications

Advances in Computational Methods in Sciences and Engineering, 4A, 2006, 112
Aiche Journal, 52(11), 2006, 3707-3721
Annals of Burns and Fire Disasters 18(2) 2006,83-88
Australian Journal of Chemistry 59(7), 2006, 463-467
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Foundation day

CLRI celebrated its 59th Foundation Day on 24th April 2006. Dr G Thyagarajan was the Chief Guest. Dr S Ramachandran, Chairman, Research Council presided over the function. A MoU was signed with the University of Northampton by CLRI. The Seminar on Innovations in Leather Science & Technology was chaired by Shri NR Jagannathan.

CSIR Foundation Day was celebrated on 26th September 2006. Prof P Natarajan, Director, National Centre for Ultra Fast Processes, Chennai was the Chief Guest. Dr NR Rajagopal presided over the function.

Overseas collaborations

The South African High Commissioner Mr HE Francis Moloi visited CLRI on 10th July 2006 for discussions on areas of mutual cooperation between the CLRI and South Africa.

The Honorable President of Botswana along with a high level team visited CLRI on 11th December 2006 for exploring areas of mutual cooperation between CLRI and leather & allied industries in Botswana.

A delegation from Thailand visited CLRI on 31st January 2007 for forging partnerships in areas of common interest.

Letter of Intent was signed between CLRI and Department of Veterinary Services, Ministry of Livestock & Fisheries development, Nairobi, Kenya on 8th February, 2007 for undertaking collaborative research and exchange of S & T personnel between the two organizations.

Annual Leather Research Industry Get-Together

Leather Research Industry Get-Together (LERIG) 2007 was organized in association with stakeholders during 27-29th January 2007. The theme of this year’s LERIG was “Benign Environmental and Sustainable Technologies” (BEST) for Indian Leather Sector. The programme was inaugurated by Dr. Sukumar Devotta, Director, NEERI, Nagpur. Mr Rafeequa Ahmed, President, ‘All India Skin & Hide Tanners and Merchants’ Association (AISHTMA), was the Chief Guest and presented MODEUROP and Design Awards. Deliberations were held on management of liquid & solid wastes, salinity reduction in leather processing, recent environmental regulations and modernization programmes. BM Das Memorial Lecture on “Reach Management” in Leather Industry was delivered by Dr Tilman Taeger of BASF Germany on the 28th January.

INDO-US workshop

The third INDO-US Workshop on “Diabetic Foot Complication” was organized jointly by MV Hospital for Diabetes and CLRI during 24-25th September 2006. The Workshop was inaugurated by Dr T Ramasami, Secretary, Department of Science & Technology.
• The First CSIR Award for S & T Innovations for Rural Development was received by CLRI for development and implementation of technologies for the livelihood of rural people living with leather.

• CSIR Technology Prize for Business Development and Technology Marketing 2006 was won by CLRI for significantly enhancing the business and markets for its knowledge base.

• Dr A B Mandal was awarded the B N Ghosh Memorial Award for the year 2006-2007 in recognition of his significant contribution in the field of colloids and surface chemistry.

• 2nd Bry-Air Awards for Excellence in HVAC & R 2006-2007 at Kolkata was received by Shri N K Chandra Babu and Shri R. Thiagu for design and development of mobile blast chilling System.

• Dr P Thanikaivelan received INAE Young Engineer Award 2006 from Indian National Academy of Engineering (INAE), New Delhi.

• Dr P Thanikaivelan won CSIR Young Scientist Award 2006 in engineering science from Council of Scientific & Industrial Research (CSIR), New Delhi for innovation of a new pollution-free route to leather processing.

• FASHION ACCESS was held from October 4 – 6, 2006 at the Hong Kong Convention and Exhibition Centre. Mr Md Sadiq, Scientist, CLRI was invited as a judge to select the ‘Best of APLF Awards’.

• Dr A B Mandal was awarded Bhartiya Shiksha Ratan Award for excellence in chosen field of activity by All India Business Development Association, New Delhi on 12\textsuperscript{th} February 2007.