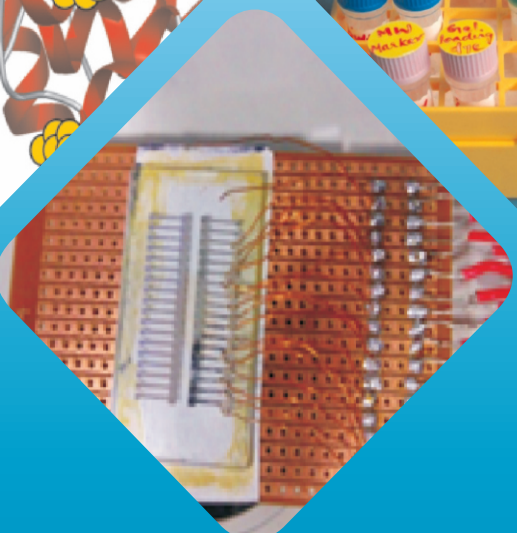
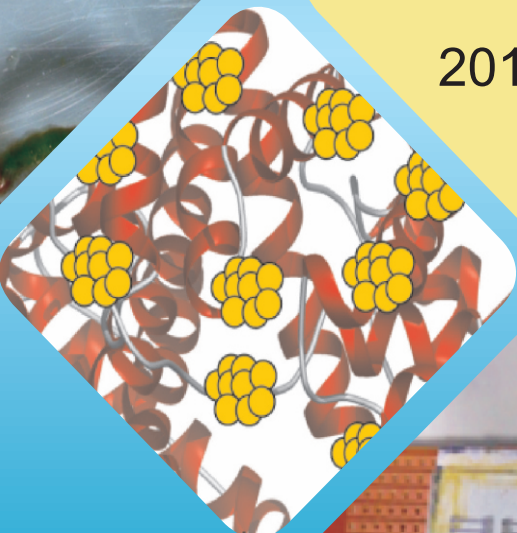
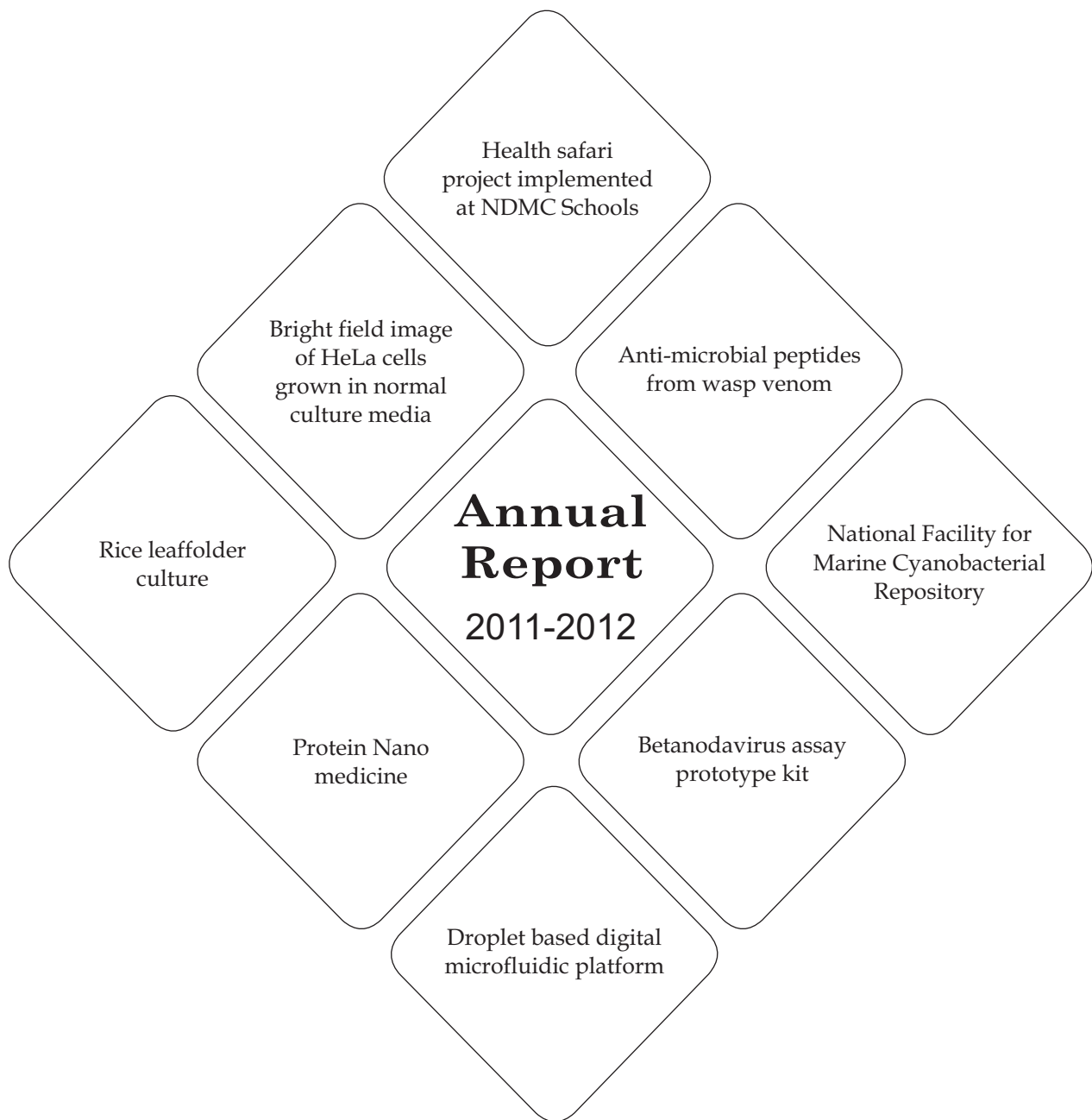


Annual Report 2011-2012



DEPARTMENT OF BIOTECHNOLOGY
Ministry of Science & Technology
Government of India



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OVERVIEW

Preamble

The year 2011-12 has been very significant in the life of the Department of Biotechnology. This year the department was rated as one of the Toppers amongst the first three Ministries/Department, by the Cabinet Secretariat in the Government's Performance Review. The department has completed 25 years of its existence and is celebrating the Silver Jubilee this year. It is therefore a right occasion for reflection.

The department has grown into a major national research and development agency presently providing nearly two-thirds of the research and development support in the life science sector. The department's initial emphasis was on creating an institutional framework for biological science and biotechnology, human resources at Ph.D. and Post Doctoral levels, creating and nurturing scientific and technology leaders in the country. The performance of department supported universities and academia institutions in this field have been par-excellence. The budgetary allocation of the department has increased from around

Rs. 23 crore in 1986-87 to Rs.1426.92 crore in 2011-12. The department moved with the progress from its single institute, National Institute of Immunology, New Delhi to 14 autonomous institutions covering the areas of plant, human sciences, industrial biotechnology, stem cell science and regenerative medicine, translational health science, biomedical genomics, agri-food biotechnology and animal biotechnology. The department is also committed to provide nearly two-thirds of its budget to Universities and non-DBT institutes.

India needs to increase quality Ph.Ds atleast by three folds. The generation of Ph.Ds and scientific publications from India are showing a major upward trend and high quality publication are increasing in number. The biotechnology industry has consistently maintained growth of approximately 28% in the last decade and nearly 46 products have been commercialized by the biotech industry in the country. Our regulatory system has matured in its quality and transparency and so has the ability to manage intellectual property, technology transfer, entrepreneurship and academia-industry relationship.

From a few simple generic schemes, we now have a large and diverse portfolio of schemes to support people, institutions and universities, to promote excellence, to initiate and effectively manage R&D networks nationally and globally. While nurturing basic and interdisciplinary science, DBT has effectively intervened to make a difference to the health sector, agriculture sector and in catalysing and supporting development and diffusion of affordable technologies. The DBT's critical role in these sectors is to sustain high-end science, technology innovation and industry-academia interaction, complementing the efforts of agencies like ICAR and ICMR.

The department has implemented over 90% of the recommendations of the national biotechnology development strategy, built excellence in basic and interdisciplinary science, and produced and nurtured human resources for innovation. Highlights of this are: establishment of seven new institutes designed to do both basic science and affordable technology; three new bioscience clusters in Faridabad, Mohali and Bangalore; full operationalization of two highly acclaimed schemes of SBIRI and BIPP/BIRAC for supporting partnership.

Other highlights include Public-Private Partnership, with about a 120 such projects in operation today, the cabinet approval

for establishing a science based totally autonomous, biotechnology regulatory authority; initiation of special programmes to create interdisciplinary life science centres in universities with 50% of our R&D expenditure in the university system. New initiatives in system biology, plant genomics and molecular breeding, human and animal vaccines, prospecting of bioresource for drugs, stem cell research and regenerative medicine, food fortification for nutritionally deprived segments of the population; affordable health technology in implant and devices using the biodesign approach are other key elements.

A device to manage faecal incontinence has been developed by the Fellows of the first batch of the Stanford-India Biodesign Programme implemented by DBT at AIIMS and IIT Delhi in collaboration with Stanford University, USA.

The goals set in the biotechnology strategy of a globally connected nationally relevant biotechnology sector are on its way of being fulfilled with a remarkable increase in our global partnership with almost every major biotechnology nation covering North America, Europe, Scandinavia, Australia, Canada, Russia and Cuba. The global partnership has been strategically done to use and leverage India's cost arbitrage for giving affordable solutions to our people. The effect of these

developments was visible in the last year when Indian biotechnology industry recorded approximately 25% growth and crossed US \$4 billion despite global recession.

The public private partnership and the increased availability of quality human resources, the ready access to research resources and our sophistication in managing technology transfer resulted in a major push towards product development. Some of this includes commercialization of three new influenza vaccines, bivalent polio vaccine and pentavalent vaccine, meningococcal-B vaccine, low cost diagnostic for several infectious diseases, such as TB, Dengue fever, celiac disease and biogeneric drugs. Major push has been given to devices through the national bio-design alliance linking engineering and medicine to produce locally relevant devices for patents and technology transfer.

The resurgence of research in application of new approaches in agriculture such as molecular breeding and application of RNAi strategy and molecular sciences in clean energy areas by the small and medium companies is evident from the analysis of the recent approvals in our public private partnership programme. Translational research has acquired a new status in the country with our efforts, while basic science continues to grow in scale and quality.

The department has signed an MOU with the partner institutions for creating “Bio-Cluster Board”, a legal entity for its management and to synergize their intellectual strength and facilities to create a seamless campus. New schemes in North-Eastern region were implemented for students from North East region for RA fellowship and Biotech Industrial Training Programme offering industrial training to fresh B.Tech/M.Sc./M.Tech students in biotechnology in industry for a period of 6 months. This program is being implemented by the Biotech Consortium India Limited (BCIL) New Delhi. Through a special programme DBT has supported more than 50 NER Scientists with Overseas Associateship for undertaking research training abroad.

The newly established institutes namely, InStem, THSTI, NIBMG, RCB, NABI and NIAB started functioning actively. These institutes are successfully generating competitive extra mural research grants and pursuing projects in area of their research. The department has established a Biotech Science Cluster in the NCR region of Delhi as an institutional model for cutting edge research aimed at utilizing the various centres of excellence for developing new hubs. InStem is developing collaborating programmes with other institutes utilizing the infrastructure and facilities available in

the cluster. The department is in the process of implementation of Shahid Jameel Committee's recommendations for supporting the projects under the Competitive Grants Scheme and introduced e-ProMIS system for online submission and monitoring of proposals effective from 1st September, 2011.

Human Resource Development

Skilled manpower is a key component for the scientific and socio-economic development of the country. For achieving this objective, the department is implementing an integrated human resource development program in biotechnology comprising of postgraduate teaching program, doctoral and post-doctoral fellowship as well as specialized training program for UG and PG teachers and mid-career scientists. The department is providing industrial training to biotechnology students to develop skills required for biotech industries in country. The department has initiated a Star College Scheme for improvement of hands on training for undergraduate science students by providing support for infrastructure development with emphasis on faculty training pursuing projects of day to day relevance and industrial exposure to undergraduate students. Under the scheme 'Star College', 46 selected colleges have been provided support for infrastructure development with

emphasis on faculty training, hands on training and industrial exposure to undergraduate students. DBT JRF and RA programmes have increasingly become popular with students, which is evident from considerable increase in the number of applicants.

Department of Biotechnology jointly with Tamil Nadu State Council for Science & Technology is supporting student research projects to develop and utilize the talent and potential of students and train them for solving specific scientific and technological problems relevant to society. Under this Scheme, financial support is provided to encourage the U.G. (Engineering) and PG students (Bio-engineering/Physics/Chemistry/Medicine/Agriculture/Veterinary/Environment /Social Sciences) enrolled in colleges and universities to take up useful minor research projects as well as dissertation work. In keeping with the advancement of global networks for the development of biotechnology and the department's priority toward capacity building in human resources, under the renamed CREST- Award (Cutting-edge Research Enhancement and Scientific Training Award) scheme, 59 candidates were selected for Specialized Training of Young Scientists in Niche Areas of Biotechnology. TWAS-DBT fellowships for Post Graduates and Post Doctoral fellowship were awarded

and five of the awardees completed the training successfully and obtained their PhD degree. The Visiting Scientist from Abroad Programme has also been enhanced. The department with Association of Biotechnology Led Enterprises (ABLE) has successfully conducted Biotechnology Entrepreneurship Student Teams (BEST) programme to encourage young doctoral students in developing biotechnology entrepreneurship and exposing them to issues in commercialization of bio-science.

Centres of Excellence and Biotech Facilities

The COE scheme provides provision for long term support in specific areas to excel, innovate and create high quality intellectual property. The department has made a tremendous progress in establishing and creating the research related infrastructural facilities in several universities/institutions. The major facilities created are next generation DNA sequencing, proteomics, platform for agriculture & veterinary science, service facilities like C-CAMP, Bangalore, and facilities for educational, teaching and training purpose. In addition, animal resource facility is expanded and the availability of synchrotron beamline made possible for the biological science community. It led to the identification of 25 novel Mtb-specific antigens, out of which 8 antigens were found to be extremely

promising in terms of protection of mice from TB infection. Studies undertaken at NII, New Delhi, led to identification of some hits to tackle bacterial, mycobacterial and malarial affliction, characterization of novel molecular mechanisms involved in biosynthesis of mycobacterial virulent lipids in *M. tuberculosis* has opened new avenues for drug discovery. High-throughput allele determination for molecular breeding was developed at ICRISAT, Patancheru, Andhra Pradesh. SNP genotyping platforms for molecular breeding applications have been developed in chickpea and pigeon pea. Efforts have also been made to deploy marker-assisted back-crossing and marker-assisted recurrent selection approaches for enhancing drought tolerance in chickpea and molecular mapping of fusarium wilt and sterility mosaic disease in pigeonpea. Computational and System Biology Research undertaken at the NCBS, Bangalore and IISc., Bangalore has led to creation of database of aligned protein domain superfamilies. A computational pipeline, Pocket Annotate has been developed. A genome wise dsRNA screen for genes involved in endocytosis using a new methodology for screening of perturbation has been completed. A BSL-3 Containment Facility has been established at the University of Hyderabad campus which is undergoing testing for certification. Immunomodulatory role of a novel protein-

chorismate mutase essential for survival of *M. tuberculosis* has been elucidated.

Programme Support has been given to the identified institution / department to create and strengthen research capabilities at university or institutional level for categorical research in different disciplines for joint research efforts and to focus on common research problems and enhancing the core competence of the institution/ department in bioreactors and tissue engineering of liver and cartilage, development of chitosan based scaffolds and silk nanofibres for bone and cartilage tissue regeneration. The department has made good progress in establishing and creating the research related infrastructural facilities in several universities/institutions. The existing repositories and depositories are being strengthened.

Research and Development

The department supports research programmes in basic and specialized fields of biotechnology across a wide range of areas and sectors to develop basic knowledge, technologies, processes and products relevant to health, environment, industry and agriculture. The department spends about two-third of its budget on R&D activities out of which, one-third of funding goes on R&D project sponsored to various institutes/

universities and another one-third budget on its autonomous institutions for pursuing research and excellence. A two-tier monitoring mechanism has been put in place to evaluate proposals and the constant endeavour is to identify leads and take them forward to processes or products.

Agricultural Biotechnology

The department has spent about 16% of its R&D budget for the agricultural biotechnology programme during the year. The projects supported under this area have shown good progress in plant molecular biology, genomics, genetic transformation, marker assisted breeding to target the important traits related to biotic and abiotic stresses, productivity and nutritional enhancement in crops. Four agricultural products viz. Cotton, Corn, Mustard and Sorghum were approved for field trials under RCGM. A network project on development and evaluation of salt and drought tolerant transgenic rice was pursued aiming towards development of salt and drought tolerant “marker-free” rice. The study suggested that the accumulation of high trehalose provide drought stress tolerance to transgenic rice plants. In a collaborative project between DBT and IRRI, fifteen Indian institutions, including ICAR Institutes, State Agricultural Universities

and Central Universities with National Research Centre on Plant Biotechnology (NRCPB), New Delhi are participating in a network mode with NRCPB as the lead centre. The programme envisages improving at least 12 popular rice varieties grown in the rainfed agri-eco systems through marker-assisted backcross breeding for flood, drought and salt tolerance.

Molecular cloning and characterization of salinity and/or drought stress-induced helicase from rice and its functional validation is being carried out at ICgeb, New Delhi. A network programme on physical mapping and sample sequencing of wheat chromosome 2A was continued. Other new projects on development of micronutrient enriched maize through molecular breeding, crop biofortification of groundnut and pigeonpea were also undertaken. A screening facility for iron and zinc bioavailability has been established. The department launched a major translational project on crop improvement where molecular markers already available in public domain for important agronomic traits in wheat, rice, soyabean, chickpea and maize have been validated and are being introgressed in the high yielding cultivated varieties suitable to specific agroclimatic zones and also at all India basis by pyramiding

genes through Marker Aided Breeding (MAB).

Biofertilizers

The department supports programmes for developing biofertilizers and technology packages for their mass production. The focus of plant protection research is on developing environmentally safe and economically feasible alternatives to chemical pesticides, using bio-technological approaches. The department also focused on conversion of industrial agricultural wastes into biomanure and manage the organic waste resources using low capital input protocols without expensive laboratories and sophisticated industrial instruments. With the departmental supports various biofertilizers and technology packages for mass production developed have already been transferred to industry for commercial production and these have contributed significantly to the agriculture production. Recently, mycorrhiza biofertilizer technology package has been transferred to an industry for the biofertilizers production and they are marketing in India and abroad. Presently, the emphasis is on development of integrated nutrient management packages for plantation crops and development of liquid biofertilizers and also on development of microbial consortia for the

effective formulation of optimal strains of plant growth promotion in rice and bio control against rice fungal and bacterial pathogens. Under an Indo-Swiss collaboration programme the bionoculants, a combination of consortia AMF and two of the Plant Growth Promoting Rhizobacteria (PGPR) resulted in enhancement of rice yield of by 26% and 30% with under field trials. The technology developed is under way for commercialization. The department has set up a Centre of Excellence at AAU, Jorhat for biopesticide production and strain improvement and new strains of bioinoculates isolated & identified and their production technology being standardized.

Bio-pesticides

A number of research projects have been supported for the control of pests and diseases of economically important crops, thereby enhancing the agricultural productivity for sustainable development. *Metarhizium anisopliae* conidia were found to be effective in controlling mealy bug in grapes. Four sex pheromone components and three aggregation pheromone components were successfully isolated and identified from *Caryedon serratus*. Synthesis of certain pheromone components has been achieved which successfully trapped *C. serratus* adults in laboratory cage experiments. Patents have also been filed

for the mass production technologies and bio formulations of certain bio control agents. Projects were implemented on formulation of mycorrhiza and agriculturally important microorganisms (AIMs). A comprehensive website on bio-pesticide has been developed for updation, up gradation and maintenance of web based knowledge resource on biopesticides. The website updated with information on more than 250 completed projects which benefits scientists, entrepreneurs and farmers.

Bioresources

Programme is being pursued on bioprospecting, inventorization and characterization, value addition and sustainable utilization of bioresources along with relevant training, capacity building and awareness generation. NBDB focuses programmes on the application of biotechnological and related scientific approaches for R&D and development of new products and processes sustainably utilizing the rich biodiversity. The largest collections of nearly 250000 microbial cultures were screened for four different therapeutic targets. A total of 16123 three stars hits were obtained of which 518 showed anti-cancer, 3643 showed anti-inflammation, 6676 showed anti-diabetic and 5286 showed anti-infective activities. These

potent cultures selected in the above exercise are being used to generate the list of 1000 cultures to be taken in the next phase of the program for identification of novel drug scaffolds. In a programme of prospecting of genes and molecules for product development, projects were supported for prospecting of novel genes, molecules, enzymes etc. from plants, microbes, fungi, lichens for production of potential products of industrial importance. Novel genes/promoters, transcription factors were identified so as to develop transgenics for biotic/abiotic stress and for understanding different metabolic engineering pathway(s) operative in a system. In a project on bio-prospecting of selected lichen and plant species for product development against cancer and tuberculosis, MSSRF has isolated four novel compounds from lichen species. The novel compound isolated from mycobiont cultures showed significant antitubercular activity against Multidrug resistant (Rifampicin and isoniazid resistant *M. tuberculosis* strains), at a concentration of 0.1mg/ml. MSSRF has established lichen cultures of *Roccella montagnei*, *Dirinaria applanata*, *Parmotrema prasorediosum*, *Ramalina pollinaria*, *Trypethelium eluteriae* and *Usnea complanata* for the biosynthesis of novel and known secondary compounds. A biopesticide formulation (Bollcure) developed from eucalyptus has been transferred to two industries. Central

Insecticide Board has approved the registration of "TERI-DBT Bollcure" for commercialization across India. Bollcure is environment friendly, suitable for both organic and IPM crop practices.

Plant Biotechnology

The department supported programmes in the area of Plant Biotechnology on basic research, forestry, horticultural and plantation crops, metabolomics etc. Nutritional and shelf life improvement programme were undertaken to enhance nutrient levels such as flavonoids, carotenoids and folate, using induced mutations/ transgenic manipulations and enrichment of Total Soluble Solids (TSS) in fruits for making tomato suitable for processing. Study is also being initiated on genome analysis of SNP's/mutations/transcriptome/proteome in cultivars and the wild accessions of tomato using whole genome sequencing and reverse genetic tools for improving desired traits. Transgenic tomato lines expressing polyamine genes under fruit specific promoter for post-harvest quality developed have been tested for post harvest quality traits.

Two transgenic lines resistant to Tomato Leaf Curl Virus (ToLCV) using antisense replicase gene have been developed and basic information generated is being taken further to develop tomato varieties with broad

spectrum resistance to (ToLCV) and Tospo virus by appropriate gene deployment strategy through marker aided selection.

A network programme was initiated on Metabolomics focusing on crops like tomato, rice, potato, maize, Arnebia, Curcuma etc. to develop complete metabolomics profile of potato, understand metabolomics of tomato with reference to fruit quality, aroma, nutritional quality, study changes in transcriptome, proteome and metabolite profile in maize (as induced by Nitrogen and Phosphorus stress), secondary metabolite pathway related to shikonin synthesis (Arnebia), metabolomics related to stress and disease resistance (rice) and assessment of therapeutic properties in curcuma.

A new variety IIHRP1 was developed and validated in farmers fields and it has been approved for release as 'Arka Flame' by Karnataka State varietal release committee. Around 73,000 certified disease free Nagpur Mandarin bud grafts have been released to growers/nursery owners in Maharashtra, M.P, Bihar, Orissa and Southern State and method for production of disease free planting material.

Medicinal and Aromatic Plants

Biotechnological intervention on medicinal and aromatic plants (MAP) was continued

for conservation, isolation and characterization of novel bioactive agents, development of herbal formulations, genomics and biosynthetic pathway studies. Important medicinal plants of Manipur hills such as *Paris polyphylla*, *Curcuma angustifolia* and *Zingiber zerumbet* have been collected and maintained in the germplasm bank at Krishi Vigyan Kendra – Sylvan, Senapati District, Manipur. A network project for identification of high camptothecin yielding clones and development of agrotechnology sustainable harvesting methods in *Nothapodytes nimmoniana* is continuing at UAS, Bangalore, UAS, Dharwad (College of Forestry, Sirsi) and Research and Action in Natural Wealth Administration, Pune. Protocol has been standardized for extraction and estimation of camptothecin from leaf tissues of *N. nimmoniana*. Over 5000 seedlings of *N. nimmoniana* were introduced into various agro-forestry systems and development of coppicing technology to maximize camptothecin yield has been developed. Efforts were initiated to develop diagnostics for better management of begamoviruses infecting *Mentha* spp at CIMAP, Lucknow. In the work undertaken on genomics and biosynthetic pathways at University of Jammu, eleven genes involved in mucilage biosynthetic pathway identified in Isabgol (*Plantago ovata*), Jammu. Studies on designing and preparation of microarray chip to analyze

the terpene pathway in aromatic plants are progressing at CIMAP, Lucknow.

Animal Biotechnology

Efforts were continued to improve the productivity of livestock animals. To enhance the reproductive efficiency of Mithun, techniques of artificial insemination, preservation of semen and embryo transfer were standardized and calves were born. Embryo transfer techniques and ovum pick up technique for harvesting Yak embryos were standardized. Transgenic mice model expressing enhanced green fluorescent protein (EGFP) gene in its mammary gland was developed using construct with EGFP gene cloned under buffalo beta casein promoter and attempts are on to express human proteins of therapeutic value in the milk of buffalo. A knockout mice model was also developed by deleting Wdr13 gene which plays an important role in obesity and metabolism. Sperm specific antigens of dogs having immunocontraceptive potential were isolated, identified and characterized. The reproductive efficiency of local sheep breed of Kashmir and Lonand strain of Deccani sheep was enhanced by introgressing fecundity B (FecB) gene and high litter size of FecB carrier sheep was reported both at experimental and farmers level. Utilization of nonconventional oil cakes as an alternate to oil cakes as a source

of protein and energy supplement in feed was studied. Suitable enzyme formulations and their encapsulation process were developed for improving the feed efficiency in poultry and pig. A new method of forced moulting in white leghorn hens using Zinc and Chromium was developed which can be effectively used at the commercial scale.

A “Translational Research Platform for Veterinary Biologicals” (TRPVB) has been established at Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), Chennai in September 2011. This platform would facilitate the translation of technologies by performing product development, validation, obtaining regulatory approvals facilitate product commercialization and also be a referral center to strengthen linkages and collaboration in the area of animal vaccine and diagnostics development, exchange of biological materials, technology assessment, supporting training, consultation and IP development.

Aquaculture and Marine Biotechnology

Projects were supported on aquaculture feed, development of therapeutic feed, identification of novel bioactive molecules, marine extremophiles, molecular characterization, induced maturation in

shrimp, production of male ornamental fish, development of molecular markers for disease resistance, diagnostics and vaccines, *in vitro* model for viral replication and development of cell lines etc. An Indo-Norway joint collaborative programme on fish vaccine development was implemented. Technologies were developed and patented with the leads obtained along with a good number of publications in this programme. Initiatives were taken for formulating a multi centric programme on whole genome sequencing of commercially important freshwater fishes - *Labeo rohita* and *Clarias batrachus*. Another programme on marine actinobacteria was also formulated for exploring novel and product development.

Seribiotechnology

Programme continued on improvement of productivity, enhancement of silk quality, host-plants interaction and post-harvest processing of silk along with utilization of by-products in sericulture. A new initiative on application of silk protein was undertaken as potential biomaterial. A Consortium Programme on Mulberry Genomics has been initiated during the year. SNP discovery and trait specific transcriptome analysis of Indian mulberry has been taken up. A pilot plant for the recovery of sericin from the waste degumming liquor of silk has been set up

with an industrial partner. A method for application of sericin to cotton knits to get a value-added finished product is under investigation with a local garment manufacturing company. BmNPV resistant strains of silkworm (*Bombyx mori*) have been developed using marker-assisted breeding jointly at Seribiotech Research Laboratory (SBRL), Bangalore and Andhra Pradesh State Sericulture Research and Development Institute (APSSR&DI), Hindupur. Studies on ethology and hybrid compatibility of various ecoraces of tasar silkworm (*Antheraea mylitta*) have been initiated at Kakatiya University, Warangal. A Consortium on Mulberry Genomics (CPMG) involving four institutions – CSRandTI, Mysore, CSGRC, Hosur, UAS, Bangalore and UDSC, New Delhi has been continued. Genomic SSR markers have been identified and mapping populations segregating for root traits and WUE established for construction of linkage map in mulberry using the co-dominant SSR markers. Silk based supermacroporous cryogel matrices have been synthesized by cryogelatin technology for exploring their potential in cell-material interactions at IIT, Kanpur. Silk fibroin-agarose cryogel composites showed fast swelling kinetics, high-water uptake and good flow rates. These have shown good cell attachment and proliferation properties during interaction with fibroblasts. Efforts have been initiated on utilization of commercial silk waste as

potential nano-biomaterial at RV College of Engineering, Bangalore. Process for extraction and preparation of nano sericin material has been standardized.

Basic Research in Modern Biology

The department through basic research programme in Modern Biology has been supporting a number of research projects to increase the competency of basic research. Important leads obtained in many of the basic research studies led have to strengthening of applied research and better understanding of the basic principles. For the first time functional expression of full length channel rhodopsin in yeast expression system has been reported at Delhi University. In another work, IISc has shown a single mammalian mitochondrial translation initiation factor to functionally replace two bacterial factors (IF1 and IF2). Studies at Chittaranjan National Cancer Institute, Kolkata have revealed that dopamine can significantly inhibit lung tumor growth *in-vivo* and *in-vitro* by targeting tumor blood vessels. The department has initiated a network program under Systems Biology with focus on resolving and understanding the regulatory dynamics of interaction between *Mtb* and the cellular component of the host using a systems level approach and combining experimental, theoretical

and computational approach. It is anticipated that such an approach may reveal new strategies for the treatment of TB infection.

Medical Biotechnology

The department has progressively increased the expenditure under the broad areas of medical biotechnology and health related aspects and spending around 30% of its R&D budget. The medical biotechnology and health related aspects included infectious disease biology, chronic disease biology, vaccine research & development and human genetics & genomics.

Infectious Disease biology

The department has promoted research and development activities in the area of infectious diseases specifically relevant to the country caused by various pathogenic agents including bacteria, viruses, parasites, fungi and others. Programs were supported to develop preventive, therapeutic and diagnostic tools for infectious diseases such as Tuberculosis, Cholera, HIV/AIDS, Hepatitis, Influenza, Chikungunya, Malaria, Leishmaniasis etc. A multiplex PCR based detection kit has been developed, validated and patented for the rapid detection of STDs caused by *Neisseria gonorrhoea* and *Chlamydia trachomatis*.

Early pregnancy associated protein-1 (Epag-1), isolated from the first trimester placental tissue, blood and urine of pregnant women during first trimester has been shown to inhibit HIV-1 entry and is found to have affinity to HIV-1 gp120. A rapid IgM ELISA assay as a diagnostic tool for dengue infection has been developed and validated.

DBT-ICMR collaborative programme on “HIV/AIDS and Microbicides” was implemented for basic and translational research on immunopathogenesis of HIV and development of therapeutic strategies. It has played an integral role in supporting the transition of anti-viral candidates from early discovery to initial clinical testing. The 2nd phase of the programme has been announced aiming at accelerating research that will generate knowledge and develop state-of-the-art technologies to provide the basis for the development of HIV vaccines and novel therapies against HIV including microbicides. In order to neutralize diverse HIV isolates, *E coli* expressed Outer Domain based immunogen (ODEC) has been shown to be highly immunogenic which resulted in neutralization of B and C subtypes. Similarly CD4Bs, a gp120 based fragment, was found to elicit better neutralization than gp120. Attempts are being made towards patenting the CD4Bs immunogens.

Chronic Disease Biology

The department is emphasising on the chronic disease area covering patho-biological aspects of various cancer, pathway discovery, drug-interventions, biomarkers etc. The curcumin clinical trials in cancer have reached a critical stage. DBT had set-up a “Curcumin Clinical Pharmacology Lab” at ACTREC, Mumbai for pharmacological assessment of curcumin and its metabolites in serum/plasma of patients on curcumin intervention. The first lot of analysis has been done. The trials on oral-pre-cancer lesions have been completed. The department has funded a project to explore the pathogenesis of idiopathic nephrotic syndrome of childhood and leads from this study are likely to provide evidence for cytokine polarization of T-helper cells. On the long-term, this study might contribute to discovery of a biomarker for the Nephrotic Syndrome disease course.

A project was pursued to determine the presence of autoantibodies against factor H in Indian children with Hemolytic Uremic Syndrome and their relation to disease severity, course and to characterize the antibodies and devise better treatments for the future. The department has funded a project towards the development of a rapid, indigenous test for diagnosis of celiac disease. An ELISA kit has been developed

under this project. The kit has been tested against well-characterized sera samples and also on sera collected prospectively from children diagnosed with celiac diseases.

An immuno-chromatographic, a rapid visual test named “**Crystal TB confirm**” was developed by scientists at University of Delhi South Campus (UDSC) for detection of tubercle bacilli in culture. This test confirms NTM versus MTB and provides results in less than twenty minutes. The kit has been launched and is being manufactured by M/s Span Diagnostics Ltd, Surat.

Vaccine Research and Development

In vaccine development phase III trial of an oral rotavirus vaccine 116E is being carrying out at VIDRC. The laboratory has GLP compliant QA/QC processes and fully validated equipment. The vaccine efficacy assays are internationally cross-validated and technicians are very well trained. Another activity relates to a research programme pursued towards developing novel vaccine delivery vectors. The group is also focusing on immunogenicity of JEV envelope protein in mice delivered using Ovine Adenovirus, development of chimeric Adenoviruses for targeted delivery of therapeutic molecules to brain, identification of the JEV attachment and receptor system

on neuronal and non-neuronal cells via a combination of molecular biology and proteomic approaches, elucidating the cellular entry mechanisms of JEV using high-resolution imaging based studies, development of high throughput assay methods (*in vitro* and *ex vivo*) to screen for novel anti-virals effective against JEV and studying the role of micro RNAs in JEV replication and pathogenesis.

Stem Cell Research

A number of programmes on various aspects of embryonic and induced pluripotent stem cells have been generated and implemented for research. Programmes have also been implemented for basic and clinical research using adult stem cells and over 45 institutions, hospitals and industry are involved in stem cell research in the country. An institute for Stem Cell Biology and Regenerative Medicine (InStem) has been established at Bangalore with its translational units at Christian Medical College, Vellore. GMP and clean room facilities have been established in various medical schools. The centre at Vellore is dedicated for translational stem cell research in a medical environment established with several basic and clinical (physician) scientists involved in stem cell research. Initiatives have been taken to enable rapid expansion of cutting edge scientific activities at InStem and new research group

have been identified for collaborative science chairs in the interdisciplinary areas to generate a vibrant atmosphere of international exchanges especially for young researchers to work on joint projects with their international collaborators. Three young scientists are being trained on DBT overseas scheme in top laboratories in USA in specific areas of application to be developed at the centre.

Bioengineering

A number of bioengineering projects have been initiated to address the challenges involved and provide new vistas required for understanding the intricacies involved in applied research. Some of the significant approaches include investigation of biomechanical factors responsible for loosening and eventual failure of an implant, developing a novel microscopic technique based on photothermal detection of metallic nanoparticle labels, designing mechanistic model for predicting the growth of aneurysms in an arterial bifurcation and developing novel intelligent peptides for targeting peptide nucleic acid into cell for an effective drug delivery vehicle. Other initiatives include development of a liver assist device for the temporary treatment of patients with acute and chronic liver failure, 3-D cellular dermal matrices for reconstructive surgery in laboratory animal

models, evaluation of alginate, chitin and chitosan bandages based on hydrogels with non-toxic ZnO/Herb *Hemigraphis alternata* nanoformulations for wound dressing applications and development of a microfluidic device to study the aggregation of the β -amyloid peptide in neurodegenerative diseases.

Human Genetics and Genome analysis

Major projects have been initiated involving clinicians, molecular geneticists and anthropologists in human genetics and genome analysis. Genetic resources are being utilized to develop baseline data on various ethnic groups for disease susceptibility and provide genetic services to a large number of families including prenatal diagnosis and counselling to affected families including tribal population and awareness among public regarding prevalence of common genetic disorders in the country like thalassemia, DMD, SCD, haemophilia etc. The department has focused on disease based human genome analysis program by setting up genetic clinics anticipating that the HGP data will be available in public domain. A human DNA profiling Bill has been formulated by the department and is being further revised based on the discussion held with the experts to bring more clarity on various issues.

Environmental Biotechnology

Environmental biotechnology research and development programmes are focused on the development and use of biotechnological tools for management of environment and biodiversity conservation. The focus was on development of mitigation technologies for climate change, microbial technologies for environmental improvement, treatment of industrial effluent, bioremediation of xenobiotic compounds and biodiversity conservation and characterization. Studies on microbial diversity of various environments and their genetic information were carried out for isolating micro-organisms that could be used in the manufacture of enzymes and a wide range of bioactive compounds, as well as in bioremediation processes. A pilot scale facility of bioreactor with working volume of 1000 liter has been established by TERI at Gualpahari. A study was carried out on utilization of biodiesel waste by *Pseudomonas sp.* for production of phenazine antibiotics. A protocol of biological production of PCN comprising raw glycerol was developed and standardized using standard culture NCIM 2141.

Nanoscience and Nanobiotechnology

Nanobiotechnology is a rapidly growing area of scientific and technological

opportunity that combines multidisciplinary approach and finds applications in a variety of areas including drug delivery system, new therapeutics, imaging, multifunctional intermediates in biomedical devices etc. DBT promoted research activities in these areas. A process was developed for the delivery of active molecules to nucleus and brain. Novel stimuli responsive graft copolymeric nanoparticles based on polymers like chitosan and fibrinogen was synthesized as a promising smart material for the controlled cancer drug delivery applications. Multimodal contrast agent based on bio-mineral nanoparticles was developed with image enhancing abilities for different medical imaging modalities such as nuclear magnetic resonance, X-ray-CT and near infrared (NIR) fluorescence, and Raman imaging, together with targeted drug or gene delivery properties. NaoZno film was used as smart food packaging material with antibacterial properties. Extensive research on Nanotoxicology is being continued to understand various physicochemical parameters associated with toxicity of different nanomaterials.

RNAi Technology Platforms

RNAi approaches are extensively being used as tool in understanding various gene silencing mechanisms. RNAi approach was used in management of diseases of

important crop and conferring attributes to the plant to combat other biotic and abiotic stresses. The department supported research projects on development and application of RNAi approach in the management of various diseases, pests, enhancing the shelf life of the fruits and vegetables and making plants to withstand biotic and abiotic stresses. Application of RNAi technology has proven as an excellent tool in the area of therapeutics.

Energy Bioscience Programme

Energy Bioscience has been identified as priority area. The department has taken a lead role in developing a research base in our country in the area of Energy Bioscience. DBT has established network of more than 50 universities, research institutes and industry in close partnership, which are working to realize the goals set in national biofuel mission. Among various bio-fuels, bioethanol and biodiesel are being focused for scale up whereas others like bio-butanol and bio-hydrogen are still at R&D stages in India. Efforts are continuing for feedstock development, biomass production and optimization of production technologies for scale-up to make them commercially viable. The DBT-ICT Centre for biosciences is giving focus on developing biotechnologies for deriving energy from renewable resources. The DBT-IOCL Centre for

Advanced Bio-energy has been established at R&D IOCL Faridabad.

Biotechnology Programmes for Societal Development

Programmes for SC/ST and Rural Population

The programmes were continued for the socio-economic upliftment of SC/ST rural and women population. Diffusion of technological know-how in proven and field tested interventions were disseminated on production of quality planting material, bio-control agents, vermicomposting, organic pepper cultivation, lac cultivation, sericulture, activities relating to animal husbandry like artificial insemination, goat rearing, quail production, rabbitry etc to the target beneficiaries. In addition various programmes were undertaken on aspects of health awareness, value addition and development of products like soya milk, flour etc. Demonstrations and trainings activities benefited a large number of SC/ST and rural people. The department also supported eight bio-events to exhibit rural products and processes for promotion and marketing at the rural level and creating awareness among the target community to take up such activities for supplementation of their income. The division is promoting new rural bio-entrepreneurship through establishment of rural bio resource complexes.

Programme for Women

The Biotechnology based programme for women is intended to benefit a large number of women by improving their socio-economic status through developing specific skills among them through various biotechnological interventions. The projects supported under this programme cover training, field demonstrations, extension activities, enterprise development etc. in areas such as horticulture, mushroom cultivation, biofertilisers, biopesticides, aquaculture, animal husbandry, poultry farming, production of diverse value added marketable products. The department has taken a major initiative during the year to address various R&D components on women health care, nutrition and hygiene related aspects. The projects supported are being implemented at the community level for the benefit of large number of women.

Biotech Product and Process Development

INDUSTRY SCHEMES

Small Business Innovation Research Initiative (SBIRI)

Small Business Innovation Research Initiative (SBIRI) is the pioneering programme of the department that

supports R&D, process and product development in industry. During the present Plan Period, the SBIRI has made a mark in the biotech sector. The efforts of the department towards promotion of small and medium enterprises focusing on scientific innovations have been appreciated by the stakeholders. SBIRI has helped many small and medium enterprises to establish proof-of-concept and to work on innovation R&D through its Phase-I funding through which the industries were supported primarily in the form of grants-in-aid. The scheme also supported industries towards late stage R&D resulting into process and product development through its Phase-II funding. As in the earlier years, this year also three Road-Shows were conducted at Kolkata, Mumbai and Kochi. The participation of the private sector was overwhelming. Such promotional activities and also advertisement of the scheme in national dailies as well as in local newspapers has resulted in a continuous flow of applications from industries. Under the scheme, the department has so far received more than 900 proposals and has sanctioned 105 projects. Around 540 industries throughout the country have approached the department seeking support under the scheme. Currently 52 projects are in operation.

Biotechnology Industry Partnership Programme (BIPP) and Biotechnology Industry Research Assistance Programme (BIRAP)

BIRAP is well equipped with required staff to execute different programmes on capacity building. It has initiated electronic journal consortium with the help of DELCON to facilitate access to experts and industry to over 900 journals and scientific literature for necessary research back up. BIRAP has a mentoring programme for supporting travel and other expenses of experts to facilitate access to important workshops, meetings and conferences. The Cabinet has accorded approval for the setting up of "Biotechnology Industry Research Assistance Council (BIRAC)" under BIPP scheme to support high risk futuristic technology and process development to make India globally competitive in biotech innovation and entrepreneurship and to create affordable products and services. BIRAC is being set up as a separate body for supporting product innovation and providing required infrastructure and services at different stages of the value chain for promoting innovation and product development and providing funding/investment for early and late stage, including Small Business Innovation Research Initiative (SBIRI), Biotechnology Industry Partnership Programme (BIPP) and Ignition grant, contract research in Industry

for public institution innovation, technology transfer and acquisition in national priority areas, promotion of entrepreneurship, incubators, parks and clusters and SME empowerment measure and schemes.

R&D Scheme

Efforts continued towards optimization and scaling-up of research leads with an aim towards commercialization of the biotech products and process development for the benefits of the society. Various schemes have been supported on creation of process analytical technology based control for downstream biotech processes, use of sub-critical CO₂ for precipitation and stabilization of ultra-fine particles of active pharmaceutical ingredients for pharmaceutical applications. Other approaches include development of matrices using polyhydroxyalkanoates from indigenous *Pseudomonas* sp. LDC-5, the process optimization for keratinase production from *Bacillus pumilus* for degradation of recalcitrant proteins, mass cultivation of the fruiting bodies of different strains of *Ganoderma lucidum* at different climatic conditions to formulate *Ganoderma* powder as potential products of nutraceutical importance and *in vitro* biosynthesis of antimalarial drug artemisinin via metabolic engineering of By-2 cells.

Biotechnological approaches to Food and Nutritional Security

Severe acute malnutrition is an important cause of morbidity and mortality in children below 5 years of age in India. An alliance has been formed among Departments of Health Research (DHR), Department of Biotechnology (DBT) and Ministry of Health and Family Welfare of the Government of India to support research to generate evidence for development of practical and scalable regimens to medically rehabilitate children suffering from Severe Acute Malnutrition (SAM) without serious complications at home/community level and/or at peripheral inpatient facilities. The department has initiated development of indigenous products suitable for rehabilitation of SAM for children and development of stable and acceptable multi-micronutrient and mineral mixture used as a part of regimes for management of SAM.

Biosafety Issues

Bio-safety research programmes have focused on facilitation and implementation of bio-safety procedures, rules and guidelines under Rules 1989, Environment (Protection) Act 1986 to ensure safety to the users as well as to the environment

from the use of Genetically Modified Organisms (GMOs) and products thereof. A three tier mechanism comprising Institutional Biosafety Committee (IBSC) at the Institute/company involved in recombinant DNA (rDNA) research, the Review Committee on Genetic Manipulation (RCGM) in the Department of Biotechnology, and the Genetic Engineering Appraisal Committee (GEAC) in the Ministry of Environment and Forests (MoEF) has been established for evaluation and approval of rDNA research and development activities, monitoring and evaluation and environmental release of genetically engineered (GE) crops.

Applications in healthcare/agriculture for import/ export/ exchange of GE materials, for conduct of pre-clinical toxicity studies, evaluation of pre-clinical toxicity study reports and subsequent recommendations to Drug Controller General of India (DCGI) for appropriate phase of clinical trials, contained/ confined field trials on GE crops etc. were examined by the RCGM and appropriate decisions taken. Though cotton is the only GE crop approved for commercial release in the country so far, several other crops like brinjal, corn, mustard, sorghum, cabbage, castor, cauliflower, groundnut, okra, potato, rice, tomato etc. are in the advanced stages of development for environmental release.

Biotechnology Information System Network (BTISnet)

BTISnet has emerged as a potential scientific network in the country comprising of more than 165 institutions. In addition to the development of state of art infrastructure and human resource, the network has also proved its capability in carrying out intensive research and development activities in bioinformatics and computational biology. A compendium on "Research Publications in Bioinformatics and Computational Biology from India" was released and skilled human resources are being promoted through the long term and short term courses and trainings. The BINC exam which is considered as highly stringent national exam is picking up well and 35 candidates have been qualified this year and is expected to grow more numbers as the syllabus has been fine tuned and courses are being conducted based on the syllabus framed for the BINC exam. Eight new BIF centers have been added to the BTISnet and in fact the new generation Bioinformatics centres are doing exceptionally well and has brought in a lot of experimental component to the Bioinformatics. NEBInet comprises of more than 25 Bioinformatics centers in North East states. Several new programmes like biotech hubs, overseas associateship, twinning R&D etc. are being implemented with the support

of NEBInet. Three major consortium projects on bio informatics in TB, Rice and Mango have shown excellent progress.

Biotechnology Parks and Incubators

Biotechnology parks have been established to facilitate product advancement and innovation through the development of a biotechnology industrial cluster and to produce biotechnologists and entrepreneurs having strong foundation in research and innovation. The incubator facilities help start up companies, provide support to young entrepreneurs who are not able to invest in facilities but have the capability to design new products and processes. With many multinational and bio-pharma companies initiating their R&D and manufacturing operations in India the demand for biotech incubators has increased. Both Central and State Governments are making earnest efforts to promote biotechnology activities in the country by setting up biotechnology parks, incubators as well as pilot projects. Biotechnology parks and incubation centres set up in different states are progressing well.

International Collaboration

International Cooperation is an instrument to address global challenges of food, health, nutrition and climate change. DBT has

entered into bilateral and multilateral strategic alliance with a focus on global challenges. These alliances promote scientific excellence through R&D and innovation towards creating opportunities for higher education training and capacity building. Concerted efforts were made towards expansion of strategic bilateral and multilateral cooperation with Australia, Canada, Denmark, Finland, Japan, Norway, Sweden, Switzerland, UK, EU and USA. The department in partnership with ABLE has successfully conducted Biotechnology Entrepreneurship Student Teams (BEST) programme for development of enterprise amongst young doctoral students and training them in techno-managerial issues.

A 'Programme of Co-operation' (POC) was signed between the Republic of India and Republic of Tunisia in 2006 for five years in the area of biotechnology with an objective to develop and support collaborative research activities in the area of agriculture and health care. The POC was extended recently for another five years on mutual agreement with a commitment to cooperate for fruitful outcomes. A 'Memorandum of Understanding' (MOU) signed between India and CNRS; France was recently renewed with an objective to establish International Associated Laboratories (LIA) in the area of biotechnology as well as to launch a new international Masters' and Ph.D. programme

in 'Systems Immunology and Genetics of Infectious Diseases (SIGID).

Autonomous Institutions

Presently the department has 14 autonomous institutions engaged in various activities of R&D innovation and excellence at par with international standard. It allocated about 25% of its total budget during the year for these institutions. The salient achievements are highlighted below:

National Institute of Immunology (NII), New Delhi

NII, New Delhi continued its activities in conducting high-quality research in the area of immunology and related sciences. The core areas of research include infection and immunity, molecular design, reproduction, development and gene regulation. A number of promising leads were reported on the biology of *Mycobacterium tuberculosis*. HisB, an important protein in the histidine-biosynthetic pathway of *Mycobacterium tuberculosis* was crystallized and preliminary X-ray crystallographic analysis reported. An agreement was signed with the National Cancer Institute in the US for undertaking clinical trials at the Sloan Kettering Memorial Cancer hospital in New York to focus on cervical cancer and check the

vaccine efficacy against ovarian cancer. The institute has been involved in clinical trial of rotavirus vaccine developed to reduce the incidence of diarrhoea or its severity in neonatal children.

National Centre for Cell Science (NCCS), Pune

The NCCS has given emphasis in the areas of cell biology, signal transduction, cancer biology, diabetes, biodiversity, infection and immunity, chromatin architecture and gene regulation, stem cell, proteomics, bioinformatics and regenerative biology. It also serves as a National Cell Repository and a training centre for animal cell and tissue culture. As the National Repository, NCCS procures and maintains various cell lines and distributes them to different Universities and Research institutions in India. In the previous year, NCCS supplied over 2300 cell lines to 120 organizations. It is committed to its contribution towards human resource development, by way of reaching out to individuals at all levels including students, teachers and researchers in India. The procedures for isolation, expansion, cryo-preservation and differentiation of stem cells into specific cell types have been optimized. The institute is making efforts in understanding the cellular and molecular mechanisms defining stem cell niche in normal organs.

National Brain Research Centre (NBRC), Manesar, Haryana

NBRC continued its focused activities on inter disciplinary science from molecular biology and genetics through psychology to neuro-medicines and bio-engineering. Scientists at NBRC focus on major classes of brain disorders, such as neurodegenerative, neuro-oncological, infective, developmental and neuro-psychiatric and conducting research on infectious agents including Japanese encephalitis, HIV and Prion diseases. As neuron-glia crosstalk is recognized to be pivotal to normal brain functions, the NeuroAIDS laboratory has broken new ground by establishing a well characterized human neuron-glia co-culture system that is used for unravelling intricacies of neuron-glia communication. Researchers are expected to develop capabilities with human brain cell culture system to understand better the HIV-1 proteins that modulate neurocognitive functions in HIV/AIDS patients. As a deemed university, NBRC is continuing its M.Sc. and Ph.D. programmes.

Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad

CDFD is continuing its basic research in related areas along with providing services for DNA fingerprinting and diagnostics.

The institute is regularly receiving and dealing with the referred cases from the judiciary and law enforcing agencies. During this year, the centre provided genetic evaluation and counselling to 1650 patients. 112 cases of judiciary and law enforcing agencies examined related to identification of deceased, maternity / paternity dispute and other related criminal matters. APEDA-CDFD centre for Basmati DNA analysis centre has analyzed 205 Basmati samples for certifying the quality and authenticity of Basmati Rice. The institute has taken new initiatives in DNA profiling to demonstrate the power of expanded application of the technology improving the system of criminal justice delivery in the country. The Centre has signed an MoU with the Institute of Life Sciences (ILS), Bhubaneswar and the State Government of Orissa, to establish its laboratory in ILS and collaborate with the Government of Orissa to provide DNA profiling services in the state.

National Institute of Plant Genome Research (NIPGR), New Delhi

NIPGR is working on computational biology, genome analysis, molecular mapping, molecular mechanisms of abiotic stress response, nutritional genomics, plant development and architecture, plant immunity, and other emerging areas. An

automated procedure was developed for identification of terpene synthase (TPS) or prenyl transferase (PT) proteins in plants using Profile Hidden Markov Model. In chickpea, interspecific linkage map has been constructed for ICCV-2 x JG-62. In the Indo-Canadian Pulse Genomics Initiative, a total of 536 SSR primers were designed from lentil, of which 196 were validated. In another legume *Trifolium alexandrinum*, a microsatellite enriched library was constructed which led to the development of 692 SSR markers. It was observed in rice that the induction of phytoalexin biosynthesis genes by UV-B rays was linked with the activation of MAP kinase. The transgenic tobacco lines over expressing CaZF produced phenotypes with improved root and shoot growth along with stress tolerance. Two stress-inducible promoters were evaluated for their activity and raising transgenics with selected target genes. In the nutritional genomics programme, stable lines of AmA1 potato developed were grown and evaluated. The transgenic potatoes have increased protein content and are safe for consumption. In rice, functional analyses of seed-specific genes and anther-specific gene promoters were undertaken to understand the crucial controls of reproductive development connected to the yield. NIPGR researchers published 61 papers in high impact journals. Three patents were filed and two technologies developed at the Institute were transferred for product development.

Institute of Life Sciences (ILS), Bhubaneswar

The institute continued its focus on infectious diseases biology, gene function as well as regulation and translational research activities. Work on identification and characterization of an immunoregulatory helminth glycoprotein was taken to its logical end. The active moiety that binds to TLR4 on the surface of mononuclear cells and inhibits endotoxemia in animals was identified to be a hexasaccharide, Chitohexose, which offered insights into evolutionary relationship between nematodes and sepsis in human population. The research on TLR polymorphism in human filariasis revealed an association of TLR2 mutants (ins/ del + del/ del) and minor allele (del) for increased risk of elephantiasis development. Studies undertaken on pathogen vibrio isolates have revealed details of genes regulating toxicity and virulence and ability to form biofilms. Molecular analysis of toxigenic *V. cholerae* strains indicated the presence of multiple ctxB genotypes. The comparative modelling approach to define the structural features of all known variants of ctxB found in *V. cholerae* including 0139 serotypes suggested subtle variations in the binding ability of ctxB variants to carbohydrate ligands of GM1 viz. galactose, sialic acid and N-acetyl galactosamine. These findings shed light on

the molecular efficiencies of pathogenic isolates of *V. cholerae* harbouring natural variants of ctxB in causing the disease, suggesting the need to consider ctxB variants in designing vaccines against cholera.

Institute of Bioresources and Sustainable Development (IBSD), Imphal

IBSD continued its efforts on sustainable utilization of bio-resources focusing on medicinal, aromatic and horticultural plants, microbial, aquatic and insect bioresources toward economic development of North East Region. Germplasm repository of Zingiberales has been further enriched by addition of 27 more species raising the collection to 289 accessions belonging to 73 species. *Bambusa manipureana* and *Dendrocalamus hamiltoni* have been selected as superior edible bamboo due to their low cynogenic glycosides content, high antioxidant properties and high level of nutrient content. Kachai lemon found as a potential root stock for production of budded mandarin orange was studied to increase yield, reduce moisture stress and Phytophthora disease incidence. A strain of *Bacillus subtilis* MTCC 548 from fermented soybean was found to exhibit very high fibrinolytic casenolytic ratio indicating high affinity to fibrin. A total of 1857 bacterial strains from NE region soil have been

found to exhibit anti-cancer, anti-diabetic and anti-inflammatory property. Bio-pesticide formulations comprising *Trichoderma* sp T-86 and *Pseudomonas* fluorescent IE 161 strains have been tested at field level for the control of soft rot disease in ginger. A low cost technique for conversion of floating aquatic biomass of Loktak Lake into compost was demonstrated to farming community of Bishnupur district and training-cum-demonstration programme on fermented soybean production technology organized through KVK, Imphal

Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram, Kerala

The major emphasis of the RGCB is on research programs in Disease Biology and Molecular Medicine. Employing cutting edge technologies, the centre is exploring the biological systems with a mission to understand the diseases processes focusing on cancer, infectious diseases, neuronal disorders, reproductive and cardiovascular diseases. A new program was started in disease biology of diabetes by taking up the management of the Institute of Diabetes, a specialty medical center belonging to the Government of Kerala. Scientists have identified a secretory factor, Cyclophilin A, a peptidyl prolyl cis-trans-isomerase in monocytic cells of THP-1 cells as well as from patients with Type 2 Diabetes Mellitus

which is released by monocytes in response to oxidative stress induced by hyperglycemia. Cyclophilin A (CyPA) is known to have paracrine and autocrine stimulatory effect on endothelial cells. CyPA secreted by monocytes could have important effects on enhancing monocyte adhesion to endothelial cells and thus in the pathogenesis of atherosclerosis in type 2 diabetes. Attempts have been made to understand at the gene level, if timing of surgery during a particular phase of the menstrual cycle plays a significant role in survival of a pre-menopausal woman with breast cancer. Important molecular events/ patterns that occur might help to determine a long term prognosis by appropriately timing the surgery and hence save lives. A number of novel mutations, in both structural and non-structural protein coding regions, were identified in CHIKV isolates by whole genome sequence analysis. The institute is also providing service facilities for molecular diagnostics for infectious diseases, cancer and cardiovascular disease, DNA fingerprinting to cater to social and criminal justice systems and DNA barcoding for plants and wildlife.

Institute for Stem Cell Science and Regenerative Medicine (InStem), Bangalore

InStem has given emphasis on building a strong foundation for core research and

educational activities in the area of stem cell biology and regeneration. The core scientific program was initiated with the appreciation that understanding stem cell functions will require fundamental investigations into basic, molecular and cellular processes. Several projects are being pursued collaboratively on protein-protein interactions, quiescence and cell cycle, signalling pathways, embryonic stem (ES) cell self-renewal, RNA biology, chromatin biology and regulatory networks. InStem core group are collaborating with scientists and clinicians internationally and within India to work on cardiac function, iPS technology, biophysics and cell biology to tackle core problem-generating cellular models of cardiac disease. Another focus of the institute is on epithelial stem cells and development, mechanisms of tumor formation and networks that control signalling and adhesion in tissue architecture.

Translational Health Science and Technology Institute (THSTI), Faridabad

THSTI is an autonomous institution established by the department to conduct innovative translational research and develop research collaborations across disciplines and professions to accelerate the development of concepts into tangible products to improve human health. THSTI's

research activities are focused in three broad areas, namely, vaccine and infectious diseases centre, paediatric biology centre, and centre for bio design and diagnostics development. A Clinical Development Services Agency (CDSA) has been established as an extra-mural Centre of THSTI. Vaccine and Infectious Disease Research Center (VIDRC) research would focus on infectious disease biology, development of animal models, and natural history of disease in population giving new insights into protective host responses and biomarker discovery for screening vaccine candidates, for novel vaccine development. The centre for Bio Design (CBD) has been set up to create medical technology innovation in India for affordable health care and to support services that extend from strategic bench work to commercialization. The primary objective is to develop a cadre of investigators of global standard in regulatory product evaluations through a comprehensive and sustained training program.

National Institute of Biomedical Genomics (NIBMG), Kalyani, West Bengal

NIBMG was established to provide an impetus to research and translation to enable an understanding of the aetiologies, prevention and treatment of diseases and a reduction in public health burden.

Inadequacy of formal training programmes in human genetics has been a serious impediment to the development of biomedical genetics in our country. NIBMG is able to fill this gap by initiating courses on genetics in medicine. The institute has been able to recruit the faculty and the faculty members are currently engaged in research, training and outreach programmes. Three core areas are developing in NIBMG – cancer genomics; genomics of common diseases and traits, including susceptibility to infections; and statistical and population genomics. The Institute has successfully generated eight competitive extra-mural research grants, including one from the U.S. National Institutes of Health. NIBMG has developed collaborations with many national and international institutions, including medical colleges and hospitals. The Institute's flagship project, the International Cancer Genome Consortium – India Project, is progressing well. This project attempts to identify genomic alterations that cause gingivo-buccal oral cancer, which has the highest prevalence in India, using massively-parallel next-generation DNA sequencing technologies.

Regional Centre for Biotechnology (RCB), Gurgaon

RCB was established under the auspices of UNESCO to be an important member institute

of the Biotech Science Cluster (BSC) at Faridabad, NCR where construction activities are under progress. Presently it is undergoing different phases of growth. Currently, the centre is functioning from its interim laboratories. A new Bill has been introduced for the establishment of the Regional Centre for Biotechnology, Training and Education as Category-II institution under the auspices of UNESCO to undertake research in the field of biotechnology and to provide for matters connected therewith or incidentally thereto. The Regional Centre having the futuristic vision of providing biotechnology education, training and research is planned to be within Biotech Science yet broad-based and multi-disciplinary. Its proposed research and educational activities are focussed to be at the interface of different disciplines of science with Biotechnology as a platform of confluence. Attempts are being made to establish a wide range of disciplines that include Biomedical Sciences, Bioengineering, Biochemical and Biophysical Sciences, Climate Science, Agriculture and Environment, Biotechnology Regulatory Affairs, IPR and Policy.

National Agri-Food Biotechnology Institute (NABI), Mohali, Punjab

NABI has taken new initiatives to study the effect of diet and its constituents on adipogenesis. Fractionated constituents of

selected cereal grains (wheat, finger millet, kodo millet and buck wheat) is being examined in human (preadipocytes/adipocytes) HPAd/ HAd and murine (3L3-L1 preadipocytes/adipocytes) cell culture models and in-vivo diet-induced obese murine models to study the molecular basis of adipogenesis. Another study was targeted on mutagenesis for modification of plant genes to design sequence specific zinc finger nucleases (ZFNs), synthetic proteins consisting of an engineered sequence specific zinc finger DNA-binding proteins used to induce double-stranded breaks (DSBs) in specific DNA sequences and thereby promote site-specific recombination and targeted manipulation of genomic loci in a variety of different cell types for developing novel traits in crop plants.

National Institute of Animal Biotechnology (NIAB), Hyderabad

NIAB, a new autonomous institution of DBT, is being established within the campus of the University of Hyderabad. The institute is aiming to harness novel and emerging biotechnologies and take up research in the cutting edge areas for improving animal health and productivity. It focuses research on infectious diseases, breeding, reproduction and nutritional enrichment and aims at translational research leading to the development of novel vaccines, diagnostics

and improved therapeutic molecules for farm animals along with promotion of bio-entrepreneurship for farm animal based products. To initiate R&D activities NIAB has hired a building very close to the site allotted to NIAB and the recruitment process for scientific, technical and administrative positions is in progress.

Bio-clusters

The department has established a Biotech Science Cluster at the NCR region of Delhi. The heads of four founding institutions namely, the National Institute of Immunology; the Regional Centre for Biotechnology; the Translational Health Science and Technology Institute and the National Institute for Plant Genome Research signed a MoU to create a new entity called the Cluster Board. The Cluster Board is an enabling mechanism by which these institutions, while maintaining their own autonomy can address not only common infrastructural and cluster-related administrative issues but also synergize their complementary intellectual strengths and facilities to create a seamless campus. This Cluster will coordinate the development of the new campus at Faridabad. Efforts are being made to create this Cluster as a legal entity. A "Centre for Molecular Medicine" has been established at this Cluster. The focus of this Centre is on infectious diseases, cancer, cell therapy and drug design.

The Bangalore Bio-cluster comprises the National Centre for Biological Sciences (NCBS), the Institute for Stem Cell Biology and Regenerative Medicine (InStem) and Centre for Cellular and Molecular Platforms (C-CAMP). These three institutions are interacting, sharing knowledge and resources on a regular basis to enrich research. C-CAMP is acting as provider, developer and enabler of technology development, scientific activity and entrepreneurship. This is an institutional model for cutting edge scientific research aimed at utilizing various centres of excellence for developing new hubs. InStem is developing collaborative programmes with other institutes utilizing the infrastructure and facilities available in the Cluster.

Public Sector Undertakings

Bharat Immunologicals and Biologicals Corporation Limited (BIBCOL) were established to manufacture Oral Polio Vaccine (OPV) to meet the tOPV requirement for Universal Immunization Programme (UIP) of Government of India. The company established in the Technology Mission of Immunization to achieve self sufficiency for the nation with respect to production and supply of high quality OPV, contributed significantly to the eradication of Poliomyelitis in the country through Pulse Polio and routine Immunization Programmes.

The Indian Vaccines Corporation Limited (IVCOL) was started as a joint venture company to undertake research and development and manufacture of viral vaccines. Concerted efforts have been made to finalize the restructuring process with new activities. After taking necessary approvals from competent authority the company has signed lease agreement with IPCL/Reliance Lifesciences, one of the promoters of the company, to initiate new activities including production of vaccines, biopharmaceuticals and set up superspeciality hospital to initiate translational research in collaboration with NBRC. To initiate the proposed activities, Reliance Life Sciences (RLS) finalized the master plan for setting up integrated life science unit along with a super specialty hospital for neuro and cardio at Manesar.

International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi

ICGEB is promoting high quality basic research and training of young scientists in broad areas of genetic engineering and biotechnology including infectious diseases, agriculture and bio-energy. Several new initiatives were undertaken during the last one year through funding from different sources including funding from DBT for Center of Excellence (CoE) and Bill Gates Grand Challenge Exploration grant for the

second phase of research. The Malaria Group received CoE funding to undertake novel interdisciplinary approaches using cutting edge technology to address important problems in the biology of blood stage malaria parasites which will generate crucial field data that will help in designing a malaria vaccine for the Indian population. The Virology Group, focusing on hepatitis viruses, HIV, Influenza virus and multiplex virus detection strategies, initiated a study during the last year to understand the role of oncogenic viruses (using hepatitis B virus as a model) in regulating origin licensing as a model for cellular transformation. The DBT has recently approved and funded the extension of Centre of Excellence Program on TB research into Phase-II to develop novel intervention strategies for tuberculosis. A new initiative was undertaken by DBT and ICgeb to establish a DBT-ICgeb Centre for Advanced Bioenergy Research at ICgeb New Delhi to take the bioenergy research to a greater height. The DBT-ICgeb collaborative centre shall be expanding its activity towards genomic, metagenomic, synthetic and systems biology areas for addressing some of the key issues of biofuel development such as finding efficient cellulolytic enzymes, developing biocatalysts for C5/C6 fermentation, generating advance biofuel molecules, and developing robust algal strains for biodiesel production. Investigations continued for exploring insect

genomes for identification of proteins that could be useful as insecticidal agents and two pro-region peptides that specifically kill neonate larvae of *Helicoverpa armigera* have been identified. The ICgeb has filed 8 patents, developed 3 technologies along with 120 publications in high reputed journals during the year.

Promotion of Biotechnology in the North Eastern States of India

The department has followed the government policy of contributing 10% of its total budget for the year 2011-12 to promote Biotechnology activities in the North Eastern Region of India. The department has taken several new major activities for the benefit of North East States. Under Twining R&D programme a total of 117 proposals have been approved towards integrated technology and product development. More than 1400 farmers have been trained on organic farming technology using bio inputs for 9 horticultural groups. A Consortium project on biotech intervention on selected medicinal and aromatic plants of NER for their effective utilisation has been implemented. Towards institutional capacity building the department launched several innovative programmes under which so far more than 90 Biotech Hubs have been established at various institutions of eight NER States. NEBInet is spreading across the North Eastern Region with more than 25

Bioinformatics centres providing lot of new avenues in the Biological Sciences for this region. Altogether 15 institutions are a part of NER DeLCON for accessing more than 900 important journals. Through a special programme DBT has supported more than 50 NER Scientists with Overseas Associateship for undertaking research trainings in abroad. The DBT AAU Centre which has been established at AAU, Jorhat has shown excellent progress towards R&D in crop sciences, human resource development and promotion of technology. Under the capacity building of NER programme a number of lab staff and PI have received short-term training in leading research labs in the country and a number of workshops and symposia have been organized in the region. A series of hands-on wet lab workshops are planned for the year 2012 to provide training in molecular biology, medical genetics and immunology.

New Legislations and Regulations

Human DNA Profiling Bill has been formulated by the department in consultation with the Centre for DNA Fingerprinting and Diagnostics, Hyderabad, to regulate the use of DNA analysis of body substance profiles; making provision for establishment of DNA Profiling Board to lay down standards for laboratories,

collection of body substances; to establish a National and /or State DNA Data Bank/Banks; to create policies for use and access to information from data bank, etc. and for matters connected therewith or incidental thereto. The Draft Bill was circulated to the ministries concerned and departments of the central government to obtain their comments and has been revised, wherever necessary, keeping those comments in view. Draft Bill has been sent to the chief secretaries of all the states for information and feedback.

Regional Centre for Biotechnology (RCB) Bill is for an international nodal point for biotechnological sciences at the interface of multiple disciplines that would be an autonomous body under statute of parliament as an institution of international importance for biotechnological education, training and research. A new Bill has been introduced for the establishment of an institution of national importance to be known as the Regional Centre for Biotechnology, Training and Education as Category-II institution under the auspices of UNESCO to undertake research in the field of biotechnology and to provide for matters connected therewith or incidentally thereto.

Biotechnology Regulatory Authority of India (BRAI) is proposed as an independent, autonomous, statutory agency to be

established through the Act of Parliament by the Government of India to safeguard the health and safety of the people of India and to protect the environment by identifying risks posed by, or as a result of, modern biotechnology and managing those risks through regulating the safe development and deployment of biotechnology products and processes. The Authority will be responsible for regulating the research, transport, import, manufacture and use of organisms and products in health care, agriculture, veterinary and environment. The BRAI Bill after cabinet approval has been sent to the Lok Sabha for introduction.

Administration and Finance

Administration and finance divisions of the

department rendered support in the implementation of various programmes. Modern multimedia equipment were procured and installed for effective presentation. An effective video conferencing system has been operational in the department. To keep pace with the growth of the department, new positions of scientists and other technical staff created last year were fulfilled. Scientists/Staff were also deputed for various training programmes to enhance their skills in relevant areas. The department also participated in extracurricular activities and performed well in various events. A Hindi fortnight was organized in the Department from 14th-30th September, 2011. The department was allocated under budget estimates an amount of Rs.1400 crores for the year 2011-12.



HUMAN RESOURCE DEVELOPMENT

Skilled manpower is an important key component for the scientific and socioeconomic development of the country. For achieving of this objective, the Department of Biotechnology (DBT) is implementing an integrated human resource development program in biotechnology comprising of postgraduate teaching program, doctoral & post-doctoral fellowship and specialized training program for UG and PG teachers and mid-career scientists. The Department is providing industrial training to biotechnology students to develop skills required for biotech industries in country. The Department has initiated Star College Scheme for improvement of hands on training for undergraduate science students by providing support for infrastructure development with emphasis on faculty training pursuing, projects of day to day relevance and industrial exposure to undergraduate students etc. A few new initiatives *viz.*, an online system for feedback by students of DBT supported teaching program and setting up of Biotech education and skill development council are under consideration of the department. Significant achievements under different programs are given below:

Teaching

Post Graduate degree program (M.Sc./M. Tech./M.VSc.)

Department initiated postgraduate teaching programs in six universities in 1985-86 to ensure high standard of teaching and to generate critical mass of trained manpower in country. The programs have been expanded to 70 universities keeping in mind regional distribution of universities, need for general and specialized courses such as agricultural, medical, pharma, food, veterinary, industrial biotech etc. Location of institutes running these programs is depicted in Figure 2.1 & 2.2. Students for DBT supported teaching programs are selected on All India basis through common entrance test conducted by JNU at over 70 centres in all parts of country or IIT-Joint admission test or University examination test. Selection process is very stringent and approximately 1 out of 60 applicants is selected. All selected students are paid studentship. Department is developing an independent on-line feedback mechanism by students for DBT supported teaching programs.

Sciences & Technology of Kashmir, Shuhama, Srinagar, J & K is under process for providing financial support.



Fig. 2.2. Map showing location of Universities/institutes running DBT supported M.Tech and M.VSc. programs

To ensure uniform standard of teaching, DBT sponsored teaching programs are periodically reviewed by expert committees *viz.*, in-house advisory committee, course coordinators meeting and DBT-HRD Task Force. The progress of DBT supported post graduate teaching programs has been evaluated based on number of criteria such as core faculty strength, mode of admission, filling up of sanctioned seats, in-house dissertation, placement of students publications during

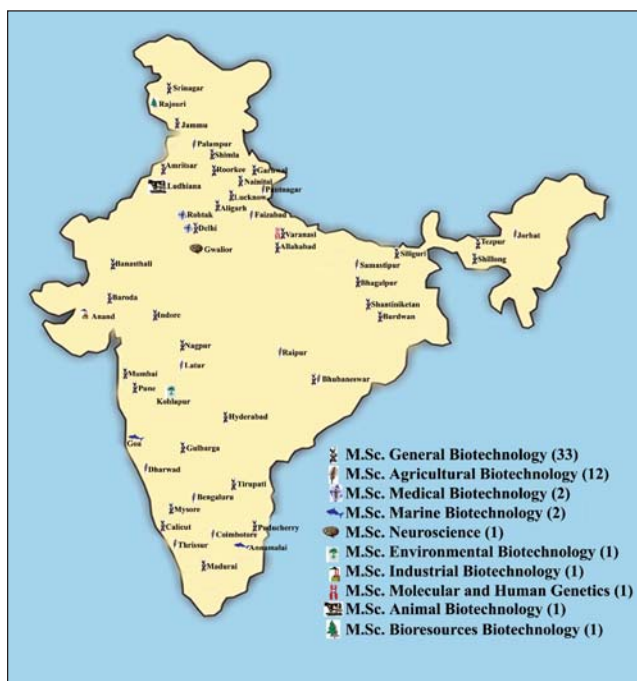


Fig: 2.1. Map showing location of Universities/institutes running DBT supported M.Sc. programmes

last five years, infrastructure created, R & D grants received by their department etc. Mentors have been identified for programs ranked low to help them to improve.

Star Colleges

“Star College Scheme” has been initiated by DBT to support colleges and university departments offering undergraduate education in life sciences to improve teaching of biotechnology component. The programme aims to improve the skills of teachers by organizing faculty training, improved curriculum and emphasis on practical training to students by providing access to specialized infrastructure and consumables. Star college scheme has been divided in two categories viz. strengthening of support for undergraduate education and Star college status. Criteria for selection as a “Star College” are very stringent and budget provision is double for colleges accorded star college status. One time non-recurring grant for equipment and annual recurring grant is provided for life science departments in selected colleges. So far, 56 colleges have been supported under the “strengthening of support” category (Figure 2.3). None of the colleges have been accorded “Star College” status. The support has strengthened physical infrastructure in laboratories, library, teaching aids, and promoted networking with neighboring institutes. Hands-on training and

projects of day to day relevance have enhanced interest among students to pursue science courses.

During 2011, advertisement seeking proposals from colleges in North Eastern Region was issued and 17 new proposals were received. In response to another call for proposals from all parts of country, 38 new proposals were received which have been evaluated by expert committee. To monitor the progress of colleges supported under the scheme, mentoring committees have been constituted to provide guidance, formulate and implement detailed plan and give suggestions to identify the shortcomings and gaps to strengthen the ongoing colleges.



Fig 2.3: Map showing location of colleges supported under Star College Scheme

Training Programmes

Short term training courses for mid-career scientists, faculty involved in undergraduate and postgraduate teaching

DBT is supporting a number of short term training courses for mid-career scientists, faculty involved in undergraduate and postgraduate teaching for upgrading skills of existing people. During 2011, 41 proposals were received and 19 were recommended for financial support by expert committee. These courses are extremely beneficial in upgrading skills of existing faculty. These specialized courses are organized in premier research institutions for duration of 2-3 weeks for 12-15 participants and provide hands on exposure to UG and PG faculty and mid career researchers on latest techniques. The list of the courses conducted during the year with support from the department (Annexure-I).

Biotech Industrial Training Programme

Biotech Industrial Training program (BITP) was initiated in 1990 for providing 6 months industrial training to fresh M.Sc./M.Tech biotechnology students. The program has been extended to B.E./B.Tech biotechnology students from 2007. The program is being

implemented through Biotech Consortium India Ltd., New Delhi. BITP provides industry-specific training to Biotech students for skill development and enhancing their job opportunities in biotech industries engaged in R & D, quality control & analysis, production & manufacturing, marketing, regulation and IPR. This program has completed 22 years and has become increasingly popular among students (Figure 2.4). There is a stringent process for screening and selection through interview by expert committee comprising of representatives from academic and industries. 652 candidates trained in 146 biotech companies (Annexure-II). About 25-30% students trained under this program are offered regular placement. 150 industries are involved in training. There is provision to place 700 candidates in industries during 2011-12.

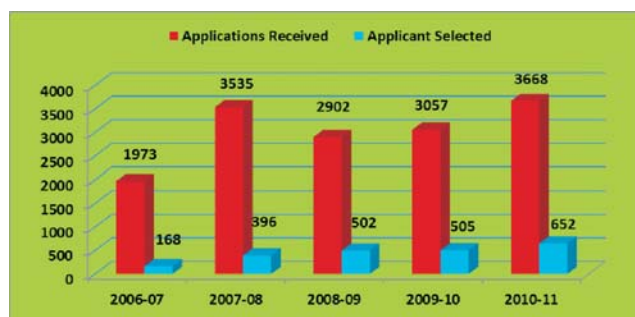


Fig. 2.4 : Number of applicants and selected candidates for industrial training during last five years

Student Research Projects

Department of Biotechnology jointly with Tamil Nadu State Council for Science and

Technology is supporting student research projects to develop and utilize the tremendous talent and potential of students and train them for solving specific scientific and technological problems relevant to society. Under this Scheme, financial support is provided to encourage the U.G. (Engineering) and PG students (Bio-engineering / Physics / Chemistry / Medicine / Agriculture / Veterinary / Environment / Social Sciences) enrolled in colleges and universities to take up useful minor research projects as dissertation work. Candidates present their findings before an expert peer group in a seminar cum exhibition. Selected projects and models are awarded.

Entrepreneurship Development Programme (EDP) in Biotechnology

Department is providing support for organizing EDP workshops in Biotechnology for setting up of new viable biotech enterprises by prospective entrepreneurs in North Eastern region. A three day workshop was organized in Guwahati by Association of Biotechnology Led Enterprises (ABLE) which was attended by 44 participants. Training mainly focused on awareness of biotech entrepreneurship including overview of Indian biotech sector, IPR and patenting, HR aspects, business plan, funding and financing, basic of

accounting, statutory and legal requirement. An entrepreneurship development program (Phase II) for advance training and setting up small biotech industry in North Eastern region has been sanctioned to Biotech Consortium India Ltd, New Delhi. This program is designed to provide the entrepreneurship development training, all the technical assistance and hand holding support for enabling entrepreneurs to set up successful industrial units in areas such as (i) Aromatic & Medicinal Plant Extraction (ii) Micropropagation (iii) Bio-fertilizers and Biopesticides (iv) Orchid culture and (v) Aquaculture/Probiotics.

Fellowships

DBT Junior Research Fellowship (DBT-JRF) Program

DBT JRF programme was initiated in 2004 to provide fellowships for biotech students pursuing research in universities and / or research institutions in the country. Students are selected through Biotechnology Eligibility Test (BET) conducted at ten centres by University of Pune. Fellowship is provided in two categories: Category A and B. Category A fellowship: Top 100 students can avail fellowship in any University/Institute in India. Category B fellowships (150 in numbers) can be availed at the DBT-Supported University/Institute

conducting teaching programs or any of DBT autonomous Institutions. The program has become increasingly popular with students as is evident from increased number of applicants during last few years (Figure 2.5).

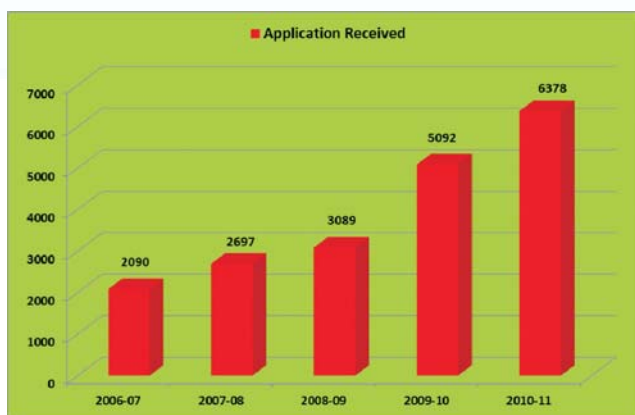


Fig. 2.5. Number of applicants for DBT-JRF during last five years

DBT Research Associateship (DBT- RA) Program

DBT Research Associateship program was initiated in 2001 to train post-doctoral students in frontier areas of research in Biotechnology and life sciences at premier institutions in India and is being implemented by Indian Institute of Science, Bangalore. The fellowship is initially awarded for a period of two years and can be extended based on review of progress. There is a provision for 100 fellowships per year. During the year 2011, in response to two advertisements, 354 applications were received and 80 candidates were selected out of 170 candidates who appeared for

interview. The fellows find placement in leading academic and research institutions in the country. The program is fairly popular with the students as is evident from increase in number of applicants over last few years while its selection process is very transparent and stringent (Figure 2.6).



Fig.2.6 : Number of applicants and selected candidates for DBT-RA during last five years

DBT-TWAS Fellowship

The DBT-TWAS (Third World Academy of Sciences) Fellowship Programme for Post Graduate Research offers two categories of fellowship (Regular and Sandwich) to young scientists from developing countries other than India who wish to obtain all or part of their Ph.D in biotechnology. While the regular programme is for those desiring to register for Ph.D in an Indian University, the sandwich fellowship is intended for applicants who have registered for Ph.D in their own country and would like to get advanced training in their field of specialization from an Indian research institute / university. This fellowship grant

is for a minimum period of 12 months and a maximum period of two years. CICS, Chennai has been co-ordinating this activity. During 2007-10, nine Post Graduate and one Post Doctoral fellowship were awarded. Five of the awardees have completed the training successfully and also obtained their Ph.D degree.

Ramalingaswami Re-entry Fellowship

The scheme was initiated in 2006 by the department for scientists working in overseas Institutions/ Universities who would like to return to India to pursue their research interests. Under the scheme each awardee receives a fellowship amount of Rs. 75,000/- pm from (consolidated), House Rent Allowance @ Rs. 7,500/- pm (consolidated). The host institute where they take up the fellowship may consider giving other benefits provided to regular faculty of the institute. So far 97 scientists from overseas institutions have been awarded this fellowship and 75 have already relocated to Indian host institutions. There is a provision of selecting up to 50 fellows per year. This scheme has been very well received by the scientific community and more and more scientists are interested in returning to the home country. This year 50 candidates have been selected. Nearly 50% of the candidates selected have joined as faculty at same or different institute. 74% of the selected

candidates have come from USA, 7%, UK, Canada 4%, Germany 3%, and 1-2% from The Netherlands, Ireland, France, Italy, Singapore, Switzerland, Australia, Japan etc. Most of the candidates selected are in the age group of 31-40 years.

Tata Innovation Fellowship

The DBT initiated "Tata Innovation Fellowship" scheme in the year 2006 to reward the scientists engaged in innovation in the pursuit of path breaking solutions to major challenges, interdisciplinary work and an emphasis on translational research in life sciences, agriculture, biomedical science and related areas of biotechnology. The awardees are provided a fellowship of Rs. 20,000/- per month in addition to regular salary and contingency grant of Rs. 5,00,000/- per annum. The duration fellowship is initially for three years, extendable further by two years on a fresh appraisal. During the current year four scientists were selected for the award of the fellowship. So far, 23 scientists have been awarded the fellowship.

Biotechnology Career Advancement and Re-orientation Programme for Women Scientist (Bio-CARe)

In an attempt to enhance the participation of Women Scientists in Biotechnology Research, the Department of Biotechnology

launched a Biotechnology Career Advancement and Re-orientation Programme (Bio-CARe) for women scientists. The programme is mainly for Career Development of employed/unemployed women scientists upto 55 years of age for whom it is the first extramural research grant. The scheme is open for all areas of Life Science / biology (including agriculture, veterinary science and medicine).

There is a Research Grant Opportunity (RGO), under which a 3-5 year research grant is provided. The purpose is to build capacities for women scientists employed fulltime in Universities and small research laboratories or unemployed women scientist after a career break so as to help them undertake independent R&D projects. Under this scheme the women scientists who are unemployed will be provided a monthly emoluments ranging from Rs. 35,000/- to 45,000/- p.m. The employed women scientists in addition to salary will get an amount of Rs.5,000/- p.m as an incentive. A research grant of Upto Rs. 50.00 lakhs is provided

In addition there is a Career Re-orientation Fellowship (CRF). This scheme is mainly for women scientists who are trained in a particular area, but leave their permanent jobs / or are unemployed and would now

like to change their career path to take on newer areas. Specialized skills would be essential and this would require training in the relevant field such as – IP management, Bioinformatics, Policy research and analysis, Translational research, Regulation etc. The training cost are borne by the Department upto maximum amount of Rupees one lakh on this training could be for a period ranging from 3 months -12 months. Under this scheme the women scientists who are unemployed will be provided a stipend of Rs.25,000/- p.m. and employed scientists will get an amount of Rs.5,000/- p.m as an incentive in addition to their salary.

There was an encouraging response and nearly 1000 applications were received. Candidates short listed based on scientific merit, academic qualification, publications were selected under the scheme. Forty three Women Scientists have been awarded the BioCARe Research Grant Fellowship during the year in all areas of Life Science/ biology. Early Career Fellowship for Women Scientists who have completed their Ph.D during last two years are also being considered to help them undertake independent R&D projects. 45 women scientists have been awarded the fellowship during the year.

Mentorship Workshops were organized in four regional centers for Women scientists

to help them to improvise their project plans and details. The workshops would also capacitate the women scientists in good grant writing and bring confidence to apply for Research Grant to different agencies. Nearly, three hundred fifty scientists have benefited from these workshops.

Distinguished Biotechnologists Research Professorship

Under the scheme “Distinguished Biotechnology Research Professorship” launched by DBT during 2008-2009 to recognize eminent scientists who had superannuated and have made outstanding contribution in their respective fields four distinguished Professors selected earlier are availing the scheme. This scheme comprises of an award of Rs.60,000/- per month and a research grant upto Rs.20.00 lakh for a period of five years or till the awardee attains the age of 70 years whichever is earlier.

Programmes for North Eastern Region

The Department has started DBT-RA programme for students from North East region (domicile or have studied for past 3 years in university / institute in North Eastern states). The program is being implemented by Indian Institute of Science, Bangalore. During the year, total 20 applications were received, 12 applicants

appeared for interview and 10 candidates have joined the RA program. Biotech Industrial Training Programme for North Eastern region offers industrial training to fresh B.Tech /M.Sc./M.Tech students in biotechnology in industry for a period of 6 months. This program is implemented by Biotech consortium India Limited, New Delhi (BCIL). Advertisement for seeking applications has been inserted in national dailies for candidates from North Eastern Region. There is provision to place 100 candidates in industries for 6 month during the year.

DBT Scholarships and Awards

Biotech Product, Process Development and Commercialization Awards

DBT gives awards in recognition of outstanding contributions of scientists / innovators / entrepreneurs / Indian institutions & companies both in public as well as private sector for a new process, product development and commercialization of a technology or a product in the areas of biotechnology and biological sciences including agriculture, biomedical and environmental sciences. Up to five awards are given every year. Each award carries a cash amount of Rs. 2.00 lakh along with a citation. Rs. 5.00 lakh would be given if the product is

commercialized and has much higher impact of utilization in the country. The awardee should be a citizen of India, and Indian institution or an Indian company actively involved in the development of biotechnology processes and products and commercialization of technologies or product based on indigenous research. During the year 2011, out of 12 nominations received, one awardee was selected for the Award of Rs. 2.00 lakh.

National Women Bio-scientists Award

The National Women Bioscientists Awards are given every year under two categories. These are (i) National Women Bioscientists Award (Senior Category) (One) –awarded to senior woman biologist for life time contributions, who has done excellent research work in the country and has applied the results for the benefit of students and society, and (ii) National Women Bioscientists Awards (Young Category) (Two) – given for outstanding contributions of women scientists below 45 years of age in basic and applied research in the areas of biosciences and biotechnology including agricultural, biomedical and environmental sciences with potential for product and technology development. Contribution made during last 5 years, is the main consideration. Each Award carries a cash prize of Rs. 1.00 lakh

along with citation and a medal. National Women Bioscientists Award for year 2011 is in progress.

National Bioscience Award for Career Development

National Bioscience Awards for Career Development are awarded in recognition of outstanding contributions of young scientists below 45 years of age in basic and applied research in the areas of biosciences and biotechnology including agricultural, biomedical and environmental sciences with potential for application/product and technology development. Each Award carries a cash prize of Rs. 1.00 lakh and a citation along with project research grant of Rs. 9.00 lakh @ Rs. 3.00 lakh per year for a period of three years for career development. Upto 10 Awards are given every year, subject to the availability of suitable candidates. Out of 55 nominations received, 10 awardees were selected for the year 2011.

DBT Biology Scholarship

DBT Biology Scholarships are awarded to students from the combined merit list of Biology/ Biotechnology at Higher Secondary/Intermediate/ 10+2 level each year to encourage students to pursue studies in biological sciences after 10+2

level. From year 2007-08, the amount of scholarship has been enhanced to a lumpsum @ Rs. 20,000/- per scholarship and the total number of students has also been increased to 100 i.e. 44 students from Central Board of Secondary Education (CBSE), 4 from the Council for Indian School Certificate Examinations (CISCE) and 52 from State Boards (2 scholarships each from 26 State Boards). The Award also carries a medal and a certificate of merit. For the year 2010-11, 89 Students (43 scholarships to students from CBSE, 4 scholarships to students from CISCE and 42 scholarships to students from State Boards) were selected for the DBT Biology Scholarship, while for the year 2011-12, details from State Boards are being obtained.

Innovative Young Biotechnologist Award (IYBA)

The Innovative Young Biotechnologist Award (IYBA) scheme was instituted by DBT in the year 2005. The award is an attractive career oriented scheme to identify and nurture outstanding young scientists with innovative ideas and desire to pursue research in frontier areas of biotechnology. This award provides an excellent opportunity for the young scientists who wish to start research career even if they do not hold a regular position. So far in last six years, 61 young scientists have been

awarded and are pursuing excellent innovative research independently which are being reviewed every year by the IYBA expert committee. These awardees have published 18 publications in indexed journals showing the impact factor greater than 7, out of which one publication in Nature Nanotechnology has the impact factor 26.31.

A total of 127 applications were received for the year 2011 awards. The short listing was carried out through online with the IYBA Experts and out of 110 eligible candidates, 52 were short listed based on the scoring of marks of 40% & above and 17 candidates were selected for the IYBA Awards.

Rapid Grant for Young Investigators (RGYI) Scheme

Rapid Grant for Young Investigators fosters creative research in various fields of biotechnology (Medical, Agriculture, Animal Biotech, Environment and Industry etc.) to enhance early career development of young investigators below 40 years of age. The programme aims to provide first grant to establish the lab and initiate research in the frontier areas of biotechnology. The scheme is under implementation since 2005-2006, it was initiated with an endeavor to release funds to young investigators within eight

weeks of the submission of the proposal. Under this scheme numerous young investigator have been supported. RGYI has been receiving overwhelming response through “Call for Proposals” and more than 2000 proposals have been received and about 320 projects recommended and sanctioned by the department based on merit for implementation. RGYI has provided start-up grants to young investigators across the country working in different settings such as central government funded institutions, State Government funded University departments, scientists at DSIR approved private institutions etc. About 100 proposals were evaluated and significant progress was observed in various projects supported on various priorities research areas.

Cutting-Edge Research Enhancement and Scientific Training Award (DBT-CREST Award)

In keeping with the advancement of global networks for the development of science and the Department’s priority toward capacity building in human resources, the ‘Biotechnology overseas associateship award’ and ‘Associateship for specialized training of young scientists’ in niche areas of biotechnology has been revised and renamed as the “Cutting-edge Research Enhancement and Scientific Training Award”

(DBT-CREST Award). Under this programme 57 candidates were selected for the award of fellowship during 2011-12. 50 fellowships are proposed to be awarded during the next financial year 2012-13.

Biotechnology Entrepreneurship Student Teams (BEST)

In an effort to encourage enterprise and entrepreneurship the Department with ABL has initiated Biotechnology Entrepreneurship Student Teams (BEST) programme. The programme aims to encourage young doctoral students in developing biotechnology entrepreneurship and exposing them to issues involved in commercialization of bio-science. They are encouraged in a competitive mode, to submit as teams business plans for scientific ideas which can be commercialized.

About 200 concepts were received and top 21 teams were selected for a 4 day residential workshop on the topics like- Role of the Entrepreneur, Qualities of an Entrepreneurial Mind, Intellectual Property - Protecting Your Idea, Teams to analyse the market opportunity of their own plans, Plenary – Market Opportunity, Validating the Market Opportunity etc.

A jury comprising academicians, managers, entrepreneurs, industry and investment

groups choose for best teams. First prize was secured by Sastra University, Thanjkavur; second prize by ICGEB, Delhi and third prize was shared by IIT, Bombay and ICGEB, Delhi

Biotech Popularization and Promotion

Online System for Financial Support to Conferences, Travel, Exhibitions & Popular Lectures (CTEP)

The department in addition to funding research projects on biotechnology and related subjects has been encouraging research professionals, academicians and students to enable them to organize conferences, participate in international events, arranging lectures by eminent scientists and promoting exhibitions in the subject of biotechnology. DBT earmarks a sizeable budget towards organizing these activities annually. The scheme has been renamed as Conference, Travel, Exhibition and Popular Lecture (CTEP).

Keeping in mind the objective of providing easy access to the professionals throughout the country to these grants, DBT has automated the entire operation through the on-line system named OSMoSys (Online Submission and Monitoring System).

Online Submission and Monitoring System (OSMoSys) helps expediting the release of grants in aid to the beneficiary institutions to promote Bio-Technology in India. TERI has been selected as an associate partner to carry out the management of this program as a complete out-sourcing assignment includes development, hosting, administration, maintenance of the system and operating it for three years.

The system has automated processes of proposal submission till the release of fund for financial support to the applicant's organization. The online system is hosted at URL (<http://www.dbtctep.gov.in>) enabling applicants to raise proposals to DBT seeking financial assistance for organizing Conferences; Seminar; Symposia; Workshop, Travel support for presenting research papers in the International Conferences which are being held outside India.

Proposals are also invited for organizing exhibitions and arranging popular lectures within India. Instructions for each type of proposal are provided to users to facilitate successful submission of proposals to DBT. The following four types of online application forms are available to seek grant from DBT.

- Financial assistance for holding national/ international Conference/ Seminar/ Symposium/ workshop

- Travel support for attending international conference/seminar/symposia/workshops
- Participation charge in organizing exhibition by DBT
- Financial assistance for organizing popular lectures on Biotechnology by experts

The TERI, New Delhi has been identified as an associate partner to carry out the

management of this program. From January 2011 to December 2011, the online system has received 361 proposals for Conference support while 739 proposals for Travel Grants and 7 proposals for popular lectures out of which 255, 491 and 7 proposals were supported respectively. Support has also been provided to DBT funded institutions for celebration of National Science Day 2011. Moreover, the department participated in 3 exhibitions in India and represented India in the India International Trade event held in Washington D.C, USA.



Fig. 2.7: Departmental participation in International Trade Exhibition held in Washington D.C, USA



BIOTECHNOLOGY FACILITIES, TECHNOLOGY PLATFORMS AND RESEARCH RESOURCES

Centres of Excellence (COEs) in Biotechnology

The programme provides a flexible model of long term support for highly innovative research, both basic and translational to create high quality state of art facilities for R&D and promote quality publications and intellectual property. During the year a total of 126 letters of intent/ concept were received in response to the call for establishment of Centres of Excellence through an open advertisement. Six new proposals funded under the “Programme Support” and two new proposals were under the category of Outstanding Scientist Research Programme.

The salient achievements of the “Center of Excellence” supported so far are as follows:

Genetics and genomics of silkmooths

In a network programme on Genetics and genomics of silkmooths implemented by CDFD, Hyderabad, Andhra Pradesh State Sericulture Research and Development Institute, Hindupur and Seribiotech Research Lab, Bangalore, three transgenic strains of

each Nistari and CSR-2 and six of their hybrids (polyvoltine x bivoltine) in silkworm using RNAi approach have been generated. Multilocal field trials of the transgenics are planned to be undertaken after obtaining RCGM clearance. Four viral miRNA have been validated for their possible involvement in inter-pathogen interaction. Two downstream regulators of sex-determination pathways genes in mulberry silkworm (*Bombyx mori*) and non-mulberry silkworm (*Antheraea assama* and *A. mylitta*) have been characterized in silkmooths.

Co-ordinated research on tuberculosis

In a collaborative project on tuberculosis research implemented by International Centre for Genetic Engineering and Biotechnology, New Delhi and University of Delhi South Campus, New Delhi, several Mtb target proteins were shown to be essential for growth for pathogen and animal models. An auxotrophic mutant of *Mycobacterium tuberculosis* with multiple gene disruptions as a vaccine candidate has been developed and evaluated for its efficacy in animal models. About 25 druggable targets

have been identified. Various inhibitors against three of these targets have been tested in collaboration with an industrial partner – M/s Sphaera Pharma.

A BSL-3 Containment Facility has been established at University of Hyderabad campus which is undergoing testing for certification. Immunomodulatory role of a novel protein-chorismate mutase essential for survival of *Mycobacterium tuberculosis* has been elucidated. A potent chemical inhibitor of this enzyme has been developed. Epidemiological studies have shown the uniqueness of the strains of *M. tuberculosis* circulating in the Indian subcontinent and could be potentially used to design intervention strategies to be adopted to combat tuberculosis in the country.

Novel paradigms of inhibitor design

Work undertaken on inhibitor design against key metabolite pathways to decimate infectious agents was undertaken at NII, New Delhi. Investigations led to identification of some hits to tackle bacterial, mycobacterial and malarial affliction. Characterization of novel molecular mechanisms involved in biosynthesis of mycobacterial virulent lipids in *M. tuberculosis* has opened new avenues for drug discovery. The role of carbohydrates in biological activity of the glycopeptidyl

antibiotics and designing strategies for antibiotic peptidomimetics using surrogate receptors of peptide / glycopeptide antibiotics of intake immune origin has been elucidated.

High-throughput allele determination for molecular breeding

At ICRISAT, Patancheru, Andhra Pradesh SNP genotyping platforms for molecular breeding applications have been developed in chickpea and pigeon pea. Efforts have been made to deploy marker-assisted back-crossing and marker-assisted recurrent selection approaches for enhancing drought tolerance in chickpea and molecular mapping of fusarium wilt and sterility mosaic disease in pigeonpea. A total of 182 Indian scientists have been trained in molecular breeding of crops.

Research on Hepatitis C Virus

In the work undertaken at IISc., Bangalore, ICGB, New Delhi, UDSC, New Delhi, ACTREC, Navi Mumbai and Center for Liver Research & Diagnostics, Hyderabad bioactive compound from *Phyllanthus amarus* plant has been found to efficiently inhibit Hepatitis-C Virus (HCV)-NS3 protease and block replication of viral RNA without showing cytotoxicity. A molecular switch for translational to

replication of HCV RNA which was successfully targeted with a small peptide to inhibit HCV RNA replication has also been identified.

Genome Science and Predictive Medicine

In a network project implemented by UDSC, New Delhi, NII, New Delhi, University of Delhi, Delhi, Indian Agricultural Statistics Research Institute, New Delhi, AIIMS, New Delhi, Dayanand Medical College, Ludhiana and Sri Venkateshwara College, New Delhi, new genes / loci for rheumatoid arthritis (RA) and ulcerative colitis (UC) have been identified after Genome Wide Association Studies (GWAS) carried out on 1500 cases each and 2000 control subjects of North Indian origin in two-stage study design namely discovery phase and replication phase. Differential contribution of multiple genes, their epistatic interactions and the role of metabolic networks in these two inflammatory disorders is the current focus of the centre.

Microbial Biology Research

Work undertaken on Microbial Biology aspects at CDFD and CCMB, Hyderabad led to delineation of a spectrum of transcription termination efficiency generated by perturbations of Rho, Nus G,

Nus A and the H-NS family of proteins in *E. coli*.

High-throughput approaches

To understand molecular basis of heterosis in rice, work undertaken at UDSC, New Delhi in collaboration with Maharashtra Hybrid Seeds Company Ltd., Jalna on transcriptomic analysis in rice. A set of seven genes has been short-listed for validation of gene / promoter function by transgenic approach. About 25 transgenic events have been obtained from two genes and the plants are being analyzed for functional aberrancies. Nine more genes have been selected for making over-expression and RNAi constructs. Initial cloning of these genes in primary vectors has been completed.

Genome Mapping and Molecular Breeding

Four mapping populations from crosses involving parents contrasting for variable amount of oil content of *Brassica juncea* have been developed at UDSC New Delhi. Meta analysis has identified one consensus QTL in a confidence interval of 2.4cM between 32.5 to 35.9 Cm. Molecular maps of three populations have been developed and these maps have been further saturated with more number of microsatellite and other PCR based markers.

Computational and System Biology Research

A database of aligned protein domain superfamilies, the superfamily alignment database update has been developed by NCBS, Bangalore and IISc., Bangalore. A computational pipeline, Pocket Annotate has been developed to identify potential ligand-binding sites by comparing pockets in a protein with a library of well-known ligand binding pockets, given the three-dimensional structure of a protein. A genome wide dsRNA screen for genes involved in endocytosis using a new methodology for screening of perturbation has been completed.

Epigenetic Research

Genome of Indian isolate of *Hydra vulgaris* has been sequenced and also its transcriptome has been characterized for the first time at IISER, Pune, CCMB, Hyderabad, ARI, Pune, CDFD, Hyderabad and TIFR, Mumbai. A database of histones and their modification and modifiers has also been developed and made freely available online. The state-of-the-art breeding and transgenesis facilities for *Hydra* and Zebrafish have been created. High-throughput studies for understanding genome-wide epigenetic patterns using neural stem cells / neural progenitor cells

in mouse models of depression and related disorders are in progress.

Programme Support

Programme Support is given to an identified institution / department (either as single institutional or multi-institutional programme) with multiple investigators in various disciplines to create and strengthen research capabilities at university or institutional level for categorical research for different disciplines through joint research effort to focus on common research problems. The mode of support contributes towards enhancing the core competence of the institution/department in biotechnology research.

The salient achievements of the ongoing activities are:

Bioreactors for tissue engineering of liver and cartilage tissue engineering have been developed and validated at Sree Chitra Tirunal Institute of Medical Sciences, Trivandrum. An electrospinning facility has been set up for the fabrication of polymer nanofibers for various tissue engineering applications. New biomaterials such as polymers, honey-comb structured polymer membranes bioceramics and components have been prepared.

Real-Time PCR based diagnostic tests have been developed for non-invasive pre-natal diagnosis of β -thalassemia using cell free fetal DNA in maternal plasma with an overall sensitivity of 83% and specificity of 71% at AIIMS, New Delhi. Out of 120 Steroid Resistant Nephrotic Syndrome (SRNS) patients, homozygous and compound heterozygous mutations were seen in 8 patients while single heterozygous variants were found in another eight patients.

An antigen detection kit using monoclonal antibodies against filarial candidate antigen SxP for field based diagnosis of filariasis has been developed at Anna University, Chennai. A more sensitive, reazurin-based fluorimetric method has been developed for detection of *Shigella*.

A serum-based biomarker for stroke has been identified through large-scale proteomics study carried out jointly at Institute of Bioinformatics, Bangalore and NIMHANS, Bangalore. The biomarker has been validated using ELISA on a larger patients cohort. Clinical utility of this biomarker is being investigated.

Chitosan / Wollastonite, chitosan / b-TCP and PVA / TiO₂ 3D scaffolds and silk nanofibres for bone and cartilage tissue regeneration have been developed at National Institute of Technology, Rourkela.

A cryopreservation protocol has been established for prevention of Mononuclear Cells (MNCs).

New techniques for In-gel detection of proteins, purification of novel enzymes and characterization of biofilm formation by force spectroscopy have been developed jointly at Anna University, Chennai and Madurai Kamraj University, Madurai. Patents have been filed for new electrophoretic technique, for production of novel media, process for protein purification and for bacterial cell imaging.

Sixty-one SNPs have been genotyped in 500 coronary artery disease (CAD) patients with a strong family history of cardiovascular disease and 500 asymptomatic controls enrolled from the community at Thrombosis Research Centre, Bangalore. Eleven SNPs have shown significant association with CAD.

A hybrid cytosine deaminase / uracil phosphoribosyl transferase, a suicide gene therapy system to induce cell death through apoptosis has been established at IIT, Guwahati. A chitosan based nanocomposite has been developed for cellular delivery of proteins and nucleic acids.

Pilot microarray studies utilizing human subcutaneous and visceral fat biopsies

revealed differentially expressed genes and their functional defects in patients with Type 2 diabetes at Madras Diabetic Research Foundation, Chennai.

FTIR imaging method has been developed for early and rapid diagnosis of drug induced liver injury at IISc., Bangalore. The method is more rapid and sensitive as compared to biochemical assays used to diagnose liver damage. Method will be further validated with clinical samples.

A human BAC library from the DNA of an ethnic Indian male (IMBL4) of normal karyotype covering the haploid human genome more than three times has been constructed at Manipal University, Manipal. IMBL4 BAC library represents the first catalogued Indian genome resource for applications in basic and clinical research.

A miRNA expression signature that can predict glioblastoma patient survival has been identified at IISc., Bangalore. This finding may be useful in development of targeted therapy and selection of high risk cancer patients for adjuvant therapy.

Transgenic high iron *Indica* rice has been developed using rice *ferritin* gene driven by endosperm specific glutelin promoter at University of Calcutta, Kolkata. Low phytase

rice has also been developed by RNAi mediated silencing of *mips* and *ipk1* genes. Molecular and biochemical analysis of T2 transgenics are in progress for selecting rice with reduced level of phytic acid.

T-3 progenics of leaf hopper resistant *Allium sativum* leaf lection (ASAL) expressing IR-64 rice plants have been established at Bose Institute, Kolkata. A full-length candidate mungbean yellow mosaic India virus resistant gene (MYMIV-R) has been isolated and characterized from *Vigna mungo*. A reference proteome map of MYMIV resistant *V. mungo* has been generated and 109 identified proteins have been registered in PRIDE database.

Co-expression of transcription factors cloned from *Eleusine corocona* enhanced drought tolerance in rice at UAS, Bangalore. A few markers associated with root, water use efficiency (WUE) and yield in rice have been identified. These have been used for marker-assisted selection to introgress traits into an elite variety of rice. Introgressed line KMP-175 of rice with superior adoption for aerobic cultivation has been transferred for multi-locational trials to the rice breeding unit at Mandya, Karnataka. An agreement has been signed with M/s Ankur Seeds to introgress the markers identified in rice by initiating a focused marker-assisted selection programme.

Long Term R&D Projects

Long-term R&D support was provided to individual investigators of high scientific caliber with publications and / or patents record at the highest level in recognition of investigators for their recent performance and future work plan. The salient achievements of long-term R&D projects supported so far under this category are summarized below:

A drug combination of curcumin and arteether was found to prevent recrudescence completely in *Plasmodium berghei* (ANKA) infected mice model at IISc., Bangalore. The combination has potential to prevent recrudescence in falciparum malaria and relapse in vivax malaria.

A new pathway for the aggregation of the prion protein has been discovered at NCBS, Bangalore. Aggregation of the prion protein leading to the formation of amyloid fibrils is a characteristic feature of prion-related neurodegenerative disorders.

Protein-protein interactions with RNA polymerase core enzyme lead to its reduced susceptibility to rifampicin used for active tuberculosis at IISc., Bangalore. A novel RNA polymerase-binding protein discovered could mitigate the effect of rifampicin on RNA polymerase activity.

Several genes associated with pathogenesis of *Magnaporthe oryzae* – blast fungus in rice were identified at MS University of Baroda, Vadodara.

Biotech Facilities and Research Resources

The department has made a tremendous progress in establishing and creating the research related infrastructural facilities in several Universities/ Institutions. Various areas supported are animal house, gene banks, repositories for microbes, plants, model organisms and infectious organisms, centres for genetic engineering etc. at different institutes and universities across the country. Along with these facilities, new facilities in the form of NMR, fMRI, green houses, phytotrons, DNA sequencing facilities for x-ray crystallography, molecular modelling and microarrays were also established. The main research highlights of the support are follows –

DBT supported 'Primate Resource and Research Center and Facility on Small Animals, an incubator for translational research' has been established at NII, New Delhi. The R&D work at the facility leads to the identification of full length promoter of buffalo beta-casein gene from buffalo genome and new process of amplifying a long length of amplicon (long PCR) from

genomic DNA of Indian River Buffalo. The promoter is cloned, sequenced and characterized in terms of its activity. The procedure will provide the basis for cloning the desired gene of therapeutic interest under the buffalo beta-casein promoter for creating the transgenic buffalo(s).

At 'National Repository for Filarial Parasites & Reagents, "Sevagram Maharashtra", a SXP/RAL2 family protein WbL2 is identified as diagnostically important candidate with 100% sensitivity and 90% specificity for detection of filarial infection. Filarial derived recombinant proteins *viz.*, BmALT-2, BmCys and WbL2 suppressed the immunopathologies associated with diseases progression, induced anti-inflammatory effect and showed therapeutic potential in rodent model of autoimmune diseases *viz.*, Type-I diabetes, rheumatoid arthritis and colitis. The filarial serum bank has a collection of more than 500 bancroftian filarial sera of different patients groups of different endemic zones.

DBT provided infrastructure support for Basic Biology Research at IISc, Bangalore. As a result of the support, IISc has performed research in many directions under the major heads of 'Pathogen biology, Biological Signalling Mechanisms and Biomolecular Architecture and Interactions'. Curcumin was shown to be a

potent antimalarial and in combination with Artemisinin, prevents parasite recrudescence in mice. Efforts are being made to generate recombinant gonadotropins for therapeutic purpose. These include production of host strains capable of producing glycoproteins with human like glycan moieties by glycoengineering the host organisms. Expression profile chaperone proteins of *Plasmodium falciparum* in malaria protein was shown to correlate with distinct physiological states of the parasite. Heat shock protein 90 form *P. falciparum* and *T. evansi* were shown to be suitable drug targets against protozoan infections. Also an inhibitor was recognized as a candidate drug.

A new algorithm 'PocketAlign' is available as a web service at <http://proline.physics.iisc.ernet.in/pocketalign/> for structural superposition of binding sites. Similarly, a new classifier incorporating ten features at the protein-protein interface was developed to further improve the discrimination between biological and non-biological contacts at the protein interface. The work helped the international community to bridge the gap in the automated availability of true quaternary structures from the PDB for all affinities and the method is freely available at <http://pallab.serc/iisc.ernet.in/IPAC/>.

For the first time, it has been shown that the volatile signals produced by fruit can show diel differences based on the activity period of the dispersal agent. Similarly, an experimental system for successful differentiation of in-house derived pluripotent stem cells viz. ES-cells and iPS-cells to cardiac lineage is developed and molecular and epigenetic regulation of its differentiation is studied. The BRIT1 (BRCT-repat inhibitor of hTER expression 1) is shown as inhibitor of cell proliferation i.e. having anti-proliferative activity.

During the 11 plan, the institute has trained 90 Ph.D. students and 209 numbers of students are undergoing training for Ph.D. The institute published about 400 publications under the programme support.

A DBT-BM14 program coordination unit (DBT-BM14-PCU) has been established at NII, New Delhi with an objective to acquire and maintain synchrotron X-ray beam line (BM14) in partnership with MRC, EMBL and ESRF to enrich biomedical research by providing access to the synchrotron beam line to the macromolecular crystallographers. So far more than 60 proposals have been processed from different institutions across India. More than 500 crystals were subjected to the synchrotron beam exposure and data set were collected for about 200 protein crystals.

Of these 30 datasets were meant for *ab-initio* SAD/MAD phasing. Till now, 28 international publications came out as part of this project.

Boost to University Interdisciplinary Life science Departments for Education & Research (BUILDER) Scheme

During the 11th five year plan, the department launched a scheme i.e. DBT-Boost to University Interdisciplinary Departments of Life Sciences for Education and Research (DBT-BUILDER) for advanced education and research for the upgradation/reengineering/remodeling/ creation of Life Science departments in central and state universities. From 2007 onwards almost 14 universities have been supported so far under the aegis of this scheme.

During the last financial year, 11 universities viz. Madurai Kamraj University, Madurai; University of Calcutta, Kolkata; The M.S. University of Baroda, Vadodara; Pondicherry University, Pondicherry; Karnataka University, Dharwad and University of Rajasthan, Jaipur; Mahrshi Dayaynand University, Rohtak; Shivaji University, Kolhapur; Patna University, Patna; Punjabi University, Patiala; and Barkatullah University, Bhopal were supported. These universities have been provided financial

support in terms of infrastructure; fellowship; faculty appointment; advanced training programmes for faculty, students and staffs. This year, after the advertisement, the department received 19 proposals under this programme which were initially screened by the Screening Committee Experts and finally four universities viz. Jawaharlal Nehru University, New Delhi; Aligarh Muslim University, Aligarh; Mahatma Gandhi University, Kottayam; and Guru Ghasidas Vishwavidyalaya, Bilaspur were selected for the further processing. Some of the achievements in some of the universities supported so far include:

**DBT-Madurai Kamaraj University
Centre of Life Sciences for Advanced
Research and Education; Madurai
Kamaraj University, Madurai**

Introduction of 5 year integrated M.Sc - Ph.D programme in Genomics Sciences in the School of Biological Sciences, Madurai Kamaraj University. 21 students have been selected and the course commenced. Teaching, technical and supporting staff positions were appointed following the University rules and regulations. The renovation work in the laboratory facility, computer lab facility, sophisticated instrument rooms etc. was completed and the first batch students and staff are using these facility.

**DBT-Calcutta University Interdisci-
plinary Life Science Programme for
Advance Research and Education**

An innovation program on Symbiotic Nitrogen Fixation has been initiated. PG labs have been renovated. Sophisticated instruments like ITC isothermal calorimeter, phosphor and fluorescence imager, atomic force microscope and total internal reflection microscope have been installed. 3 M.Sc. and 8 Ph.D. students have been registered and 5 technical staffs have been recruited.

Scientific progress

Group-1: Biomedical Science

Molecular mechanism of diseases: Under the Pathophysiology and molecular mechanisms of cigarette smoke-induced degenerative diseases study, a major long-lived radical from cigarette smoke was isolated and characterized as p-benzosemi-quinone which is responsible for cigarette smoke-induced degenerative diseases.

Biomarkers: In order to identify diagnostic markers in diabetes mellitus associated cardio-vascular disease, the participating group studied the effect of oral hypoglycemic agent metformin on the status of some important oxidative stress markers viz. ROS, AOPP and pentosidine.

Drug-development and nano-based drug delivery: Chandipura virus (CHPV) has recently been classified as an emerging human pathogen in the Indian sub-continent. Recent work focused on the development of effective peptidomimetic approaches towards the inhibition of viral replication cycle of CHPV in culture cells.

Group-2: Pathogenic host-microbe interaction

Fungal infection by *Macrophomina phaseolina* severely affects the production of jute. They have identified and isolated the differentially expressed transcripts induced upon *Macrophomina phaseolina* infection in jute by differential display analysis.

Under phyto-remediation study, twelve endophytes were isolated from surface sterilized *Typha angustifolia* plants collected from the uranium mines of jaduguda.

Group-3: Microbial ecology

Microbial-diversity: In order to understand the vast microbial diversity of Sunderban, a large-scale metagenomics study has been carried out on both water and soil samples collected from Jharkhali area.

Bioremediation: A new *Pseudomonas* strain having Polyethylene succinate (PES)-

degradation ability had been isolated from soil rich in recalcitrant materials that can efficiently degrade PES and use it as sole carbon source for survival.

Industrially important enzymes: Cellulose and Xylanase producing *Penicillium citrinum* and *Simplicillium obclavatum* bacterium from soil has been isolated.

DBT-Centre for Cellular and Molecular Biology, University of Baroda Interdisciplinary Life Science Programme for Advance Research and Education, Vadodara

The foundation of Central Building named as Vikram Sarabhai Science Block, is laid and construction has started. Sophisticated instruments like FACS, Confocal microscope, fluorescent microscope and ultracentrifuge have been installed in a temporary facility and are being used by the research scholars of the University. Efforts are initiated to start a five year integrated programme in Cellular and Molecular Biology by academic year 2012 in collaboration with NCBS-TIFR, Bangalore, TIFR, Mumbai and visiting faculties. Faculty level syllabus Committee has been constituted.

In order to use stem cells as therapeutics, an interesting aspect has been worked out

under the project micro RNA profiling of cord blood derived mesenchyme stem cells (MSCs) and differentiated cells and its role

in lineage differentiation and homing potential.

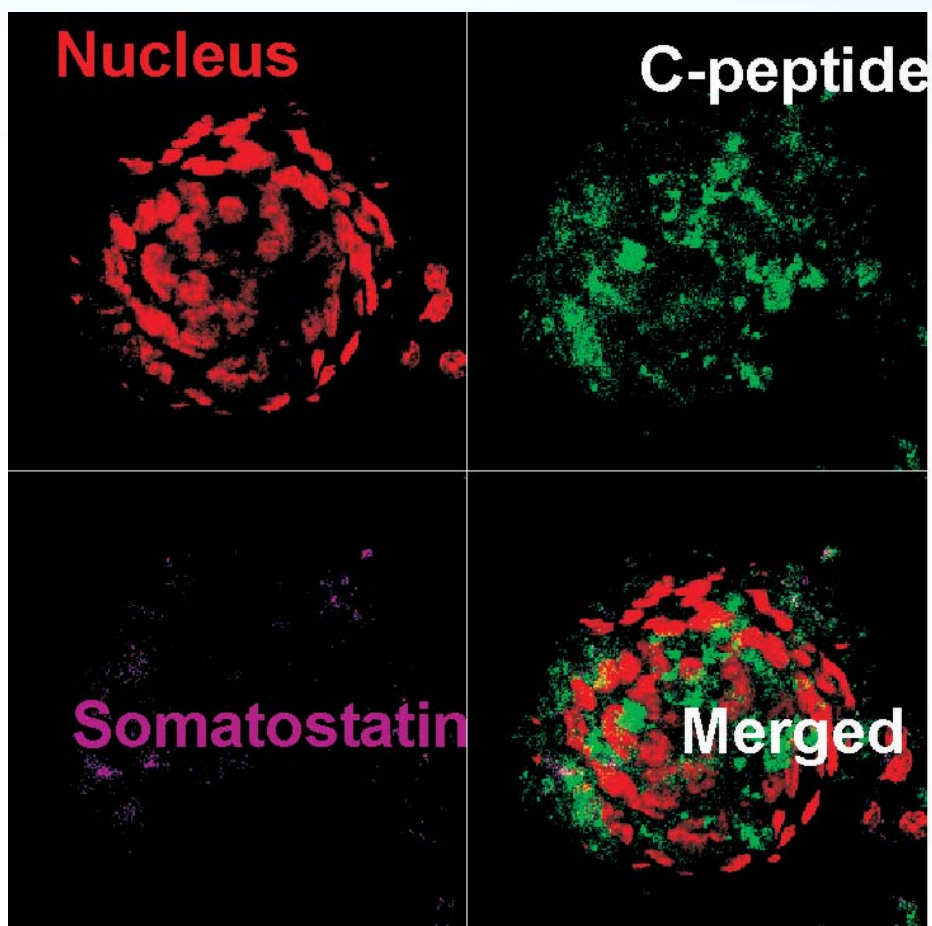


Fig.3.1: Stem cell differentiation and islet neogenesis



RESEARCH AND DEVELOPMENT

Support to research and development in different sectors is a major activity of the Department. While potential investigators routinely submit R&D proposals to the Department for funding, projects are also generated in priority areas through brainstorming sessions and expert consultations held under the aegis of various task forces and other expert committees. The Department has launched a new online project submission and monitoring system (e-ProMIS) and has adopted a new competitive research grant process. The projects are funded for basic and applied research for cloning and characterizing genes of importance, promoters, QTLs, developing enabling technologies, value added bio-mass and products from natural resources and processes for improving productivity, healthcare, remedies for environmental problems and industrial production.

Agricultural Biotechnology

Crops

Rice

Molecular cloning and characterization of

salinity and/or drought stress-induced helicase from rice and its functional validation is being carried out at ICgeb, New Delhi. Stress-responsive helicase (1.3 kb) called BATI helicase from rice has been cloned and found to be up regulated in response to salinity and cold stresses. The expression and purification of the BATI protein is in progress.

In another project of basic nature, suppression of innate immune response of rice by bacterial effector proteins has been studied at CCMB, Hyderabad. *Xanthomonas oryzae pv. Oryzae* (Xoo) uses a type 3 secretion system (T3S) to suppress rice innate immune responses. Using Agro-bacterium mediated transient transfection assays, it was shown that the XopN (Xanthomonas outer protein N) protein suppresses the rice immune responses like, innate immune response associated programmed cell death (PCD) reactions; innate immune response associated callose deposition in rice leaves that is induced by Xoo LipA or a T3S Xoo mutant; resistance against Xoo infection that is induced by prior treatment with T3S mutant of Xoo. The group has cloned genes for 15 other T3S secreted proteins of Xoo

into Agrobacterial vectors and introduced them into plant cells via transfer.

In a project for enhanced nutritional content at UAS, Bangalore, nearly 100 segregants showing high protein content (12-15%) that were identified in the F_6 population were analyzed for lysine and methionine content and cooking quality/nutritional parameters. Several promising inbreds with preferred plant type and enhanced nutrition and good grain quality have been identified with medium to early duration. These promising inbred are being evaluated in multiple environments and under contrasting moisture regimes. Also high protein inbred lines for drought, aerobic and puddled conditions were identified. Several high protein introgression lines in popular background are being developed through marker assisted backcrossing using MAS.

For developing two line hybrids in rice (*Oryza sativa* L.) good results were obtained at TNAU, Coimbatore. Thirty suspected TGMS lines were identified for TGMS sterility under high temperature regime and reversion to fertility under low temperature regime. Eight promising TGMS lines viz., TS0912, TS0914, TS0915, TS0917, TS0924, TS0925, TS0926 and TS0928 were characterized for CST/CFT, sterile and fertile phase, critical stages of thermo sensitiveness, safe period for hybrid seed

production and TGMS multiplication. These promising TGMS lines will be utilized for two line hybrid development programme.

Wheat

In a project on improvement of biscuit making quality of Indian wheat, studies were undertaken on genotype utilizing soft wheat germplasm lines including Indian land race of wheat, Nap Hal, and synthetic hexaploids. Nap Hal, a unique Indian land race of wheat, was identified for possessing both weak gluten and soft grain characteristics. Weak gluten is caused by double null trait at *Glu-Di* locus where both the subunits of HMW glutenins coded by the locus are absent. Double null trait Glu-DI locus has been transferred into high yielding backgrounds using molecular approach for improving biscuit making quality of Indian wheat.

In another project, identification and characterization of differentially expressed genes during heat stress in wheat has been undertaken at UDSC, New Delhi. Some of the heat stress-related ESTs chosen for a detailed characterization are the *TaHSF*, *TaHSP26*, *TaMIPS2* and a *TaMP*. Real time analysis found HSF to be induced by calcium, salt ABA, PEG and heat stress, particularly in various flower and seed tissues. *Arabidopsis* T_4 lines over expressing these ESTs are being characterized.

Maize

In a project on molecular characterization and introgression of QPM for maize quality improvement through marker assisted selection, the non-QPM inbred lines are being converted into QPM version. Recovery of homozygous plants carrying *o2* locus has been achieved. These lines are now being fixed for the *o2* allele before using them for generation of QPM hybrids.

Sorghum

Study is being carried out at NRCS, Hyderabad towards establishing the role of volatile cues in oviposition preference of sorghum shoot fly, and identifying associated QTLs. The role of volatiles and epicuticular waxes in oviposition behavior of shoot fly on sorghum plants has been identified. Further the volatile compounds were identified in the shoot fly susceptible parent 296B and susceptible RILs. In addition to the pronounced quantitative variation, substantial qualitative variation was also noticed among the parents.

Pearl Millet

In a study towards generation of mapping populations and identification of QTL(s) for Downy Mildew Resistance in Pearl Millet, lines were screened for downy mildew

resistance against three isolates Sg384, Sg445 and Sg561 representing three locations Barmer, Rajasthan, Banaskantha, Gujarat and IARI, New Delhi respectively. Resistant and susceptible lines were selected for crossing to generate mapping populations segregating for isolate-specific DM resistance.

Ragi

Isolation and validation of salt tolerant genes in Ragi (*Eleusine coracana* L.) is being carried out at TNAU, Coimbatore. Extreme rice and ragi genotypes exhibiting contrasting level of salinity tolerance have been identified. Physiological studies revealed the superiority of Trichy 1 ragi in terms of salinity tolerance. Protein profiling has resulted in the identification of key protein exhibiting contrasting behavior in the extreme ragi genotypes. Rice homologs of putative candidate genes controlling salinity tolerance have been isolated and cloned.

Plant Molecular Biology Programme

Stress-associated proteins (SAPs) that interact with self and kinase in different sub-cellular locations, viz *OsSAP11* and *OsRLCK253* have been identified. These have been shown to confer stress tolerance on transgenic rice seedlings. Two stress-responsive promoters

have been characterized in transgenic rice. CRY1 over-expression regulates plant height by altering the expression of gene involved in GA metabolism, auxin signaling and transport and cell wall modification. The response regulator, OsRR6, a component of two-component sensor regulator system, functions to intergrate hormone, light and stress signaling pathways, as revealed by over-expression in *Arabidopsis*. Full length cDNAs of five TaSERKs from wheat have been cloned for functional analysis. Doubled haploid transgenic of wheat over-expressing HVA1 gene conferring drought tolerance with faster seed germination and seedling establishment have been identified. Rice ClpB/Hsp100-cyt protein gene family has been characterized.

Network Programmes

Physical Mapping and Sample Sequencing of Wheat Chromosome 2A

BAC libraries were developed from flow sorted chromosomes of Chinese Spring double ditelocentric stocks ($2n = 42 + 2ASt'' + 2Alt''$) in collaboration with Institute of Experimental Botany, Czech Republic. Both short arm and the long arm of chromosome 2A have been sequenced using two NextGen sequencing platforms Illumina and Roche 454, in collaboration with TGAC, Norwich, UK. For 2AS, about 131, 603Mb

(>300x) and for 2AL about 50,000Mb (96x) sequence is already generated. As many as 264,555 contigs for 2AS and 321,517 for 2AL have been generated. N50 values for 2AS and 2AL assemblies are 2398bp and 2688bp, respectively. As many as 1908 genes have been predicted from 2AS and 2872 genes from 2AL. Using this data more than 6000 SSR markers have been identified, which are now being validated. Further, sequencing of 4608 BAC clones has been completed from both the ends and nearly 46,00,000 bp of wheat genomic sequence has been generated. An average read length of ~500 bp per BAC end has been achieved. The BAC end sequences were searched for any significant homology in the assembled EST database. As many as 3702 BAC ends find homology in the clustered-ESTs and 96 BAC ends showed positive hits with the protein database Uniprot-Swissprot.

Functional analysis of gene regulatory networks during flower and seed development in rice

While working towards delineation of gene regulatory network leading to reproductive development in rice, substantial progress has been made towards characterization of key components and their down- and up-stream interactors. For floral transition and early flowering events, orthologs of various components of *Arabidopsis* photoperiod,

vernalization, GA and autonomous pathways have been identified from rice with the eventual aim to decipher unique components, if any, involved in regulating flowering in a dicot and monocot species and that too with contrasting photoperiodic sensitivity. Four promoter elements, Pan3-CRP, PP12, M2 and RP6, have been validated for their expression in reproductive tissue-specific. Pathway analysis of differentially expressed genes has implicated hormone biosynthesis pathways as major regulators of early seed development. The marker-free, transgene-stacked rice plants for two traits (Chitinase and Osmotin genes) were generated by sequential retransformation. These plants displayed more than 60% resistance to the sheath blight disease caused by *Rhizoctonia solani*. A pMVIGS system has been used to carry out virus induced silence the rice gene *phytoene deaturase*.

Identification and functional analysis of genes related to yield and biotic stresses

At DRR, Hyderabad fine mapping and introgression of yield QTLs from wild species is being pursued. Yield QTL *yld2.1* from *O. rufipogon* has been introgressed into a parental line KMR3 for fine mapping this QTL. In another study on mapping of dense panicle trait is being followed using two introgression lines derived from Swarna X

O. nivara: 166-30 with dense panicle and 166-2-1 with lax panicle of Swarna x *O. nivara*) at 5 locations was in top 5 of 16 entries and was promoted to Advanced Variety Trial 2-IM 2011.

At NRCPB, IARI, New Delhi, a major effect QTL for grain number qGN4-1 on the long arm of chromosome 4 localised with flanking markers HvSSR04-41 and HvSSR 04-46 is targeted for fine mapping, identification of candidate genes and functional validation. The full length GN4-1 gene is being cloned and mobilised into pCAMBIA vector for possible transformation of rice lines.

At PAU, Ludhiana, *Xa30(t)* gene identified from *Oryza nivara* and transferred to *O. sativa* L has now been redesignated as *Xa38*. This gene has been mapped based on sequence information and gene specific markers have been developed for use in MAS. Two more BB resistance genes, *xa-g* from *O. glaberrima* and *xa-b* from *O. barthii* have been mapped on chromosome 6S and linked markers developed for use in MAS. Inheritance of bacterial blight resistance in an accession (100098) of *O. rufipogon* is being studied here.

At NRCPB, blast resistance studies were perused in TP-Pi54 rice transgenic plant. After inoculation with the blast spores *Pi54* gene expression was found higher in transgenic *Pi54* plants. At DRR, Hyderabad,

two or three of the blast resistance genes *Pi1*, *Pi2* & *Pi54* have been introgressed in the background of BPT5204 and Swarna.

In area of gall midge resistance, at DRR, Hyderabad, two of the gall midge resistance Gm8 and Gm4 conferring wide spectrum of resistance have been mapped. They are now being fine mapped, clone and validated for their function in collaboration with ICGEB, New Delhi.

At DRR, Hyderabad, brown plant hopper resistance studies in two mapping populations showed that resistance for the trait polygenic.

Generation, Characterization and use of EMS induced mutants of upland variety Nagina -22 for functional genomics in rice

During this period, a total of 507 selected mutants have been grown in the mutant garden and all these have been described by distinctness, uniformity and stability (DUS) parameters. These data along with other valuable information including DNA fingerprints have been entered in the Rice Mutant Database. About 4120 mutagenised lines have been maintained at NRCPB, New Delhi. Characterization of 15 lines for drought tolerance, gene expression profiling using microarrays to identify genes for seed size, plant architecture, and drought

tolerance, fine mapping of genes and allele mining for DREB1, Hd3a and PTF1 genes by TILLING has been done. DUS characterization of 89 mutants, phenotypic evaluation of 295 mutants contributed by different centers has been done.

***Puccinia triticina* - Genomics Network**

The sequencing of *Puccinia triticina* was done using 454 GS FLX sequencers. Assembled large contigs represented 102 MB of genome. Assembled data consists of 12984 large contigs and 2301 scaffolds. A total of 24005 genes were predicted out of which 17528 genes were protein coding while 3114 genes were TE related. A total of 16373 SSRs were found in the genome which includes 64% of mono-nucleotide.

In another experiment, behavior of select pathotypes was observed on Near Isogenic lines or lines with known resistance genes at two temperature regimes. Some of the resistance genes have shown effect of temperature on the expression of host pathogen interactions. At TNAU Centre, the rust reaction of the lines carrying leaf rust resistance genes *Lr24* and *Lr9* has been studied. Three wheat genetic stocks including one leaf rust susceptible (PBW226) and their resistant NILs (HW 2016+*Lr24* & HW2057+*Lr9*) were used for comparative transcript profiling.

Generation of salt-tolerant rice plants: A translational approach

At Bose institute, Kolkata; advancement of the earlier transgenic plants harboring *PcINO1* (both in PB1 and IR64 var.) have been done upto T4 stage and molecular and physiological characterization carried out following identification of salt-tolerant lines. From growth pattern in presence of salt and the photosynthetic efficiency analysis it was found that the transgenics were salt-tolerant and photosynthetically as efficient as the control plants, sometimes more efficient than the control.

Identification of candidate genes for enhanced water use efficiency in rice through activation tagging

Transformation work was initiated in all the four network centres viz., HCU, Osmania University, DRR and ANGRAU, with the variety BPT5204 with the gene pSQ5. Confirmation studies for these transgenics are underway.

Crop Bio-fortification

Biofortification of wheat for micronutrients through conventional and molecular approaches

A large number of germplasm lines including

cultivars, landraces, wild species etc. have been screened for grain Fe, Zn and yellow pigments (in durum). Accessions/lines having grain Fe and Zn concentrations two to three folds higher than in the modern wheat cultivars identified. At IARI, New Delhi, synthetic derivatives and *T. spelta* accessions have been used in collaboration with HarvestPlus. At IIT, Roorkee, the non-progenitor genomes carrying accessions of *Ae Kotschyii*, *Ae. peregrine* and *Ae longissima* etc., have been used as donor sources while PAU have primarily used *T. monococcum* and *T dicoccoides* as a high zinc and iron source to develop introgression and addition lines. The work in Phase I also highlighted that the chromosomes 2 and 7 harbor genes/segments for higher iron and zinc concentration and phytosiderophores. Five different QTLs linked to yellow pigment were identified on chromosome 1A, 3B, 5B, 7A and 7B in durum.

Rice Bio-fortification with Enhanced Iron and Zinc in high yielding non-basmati cultivars through marker assisted breeding and transgenic approaches

Procedures for precise estimation of iron and zinc concentration in grains were standardized using Atomic Absorption Spectrometer and 2, 2-dipyridyl agent. Necessary infrastructure facilities have been created for accurate screening of micronutrients. More than 3500 rice accessions including ~252 rice landraces of

CG collection known for high grain nutritive value, ~100 popular rice cultivars and ~650 advanced breeding lines developed through various breeding populations has been screened. Low genetic variations for grain Fe levels were observed compare to that of grain Zn contents. About 14 genotypes have been identified with high Zn content in polished grains ranging from 26ppm to 32ppm.

Development of micronutrient enriched maize through molecular breeding

Extensive evaluation of maize genotypes indicated the availability of large variation for kernel Fe and Zn concentration in maize. The promising inbreds thus identified have great potential as donor in the breeding programme. Research efforts presently under progress to identify QTLs for kernel Fe and Zn would further help in expediting the enhancement of micronutrient concentration. The project is thus expected to result in the development of maize inbreds and hybrids enriched with higher iron and zinc content.

Crop biofortification of Groundnut and Pigeonpea

Over 90 primary transgenic events of groundnut (var. JL 24) carrying maize phytoene synthase gene (*psy1*) driven by an *At oleosin* promoter (for seed-specific

expression in oil bodies) were characterized at the molecular level to study the introduction, expression and stable transmission of the transgenes. Inheritance studies indicated a Mendelian segregation in most of the transgenic events. The selected positive transgenic events were advanced to T2 generations for biochemical analysis. These events were characterized based on their carotenoid profiles, several of which showed a multi-fold increase in the levels of β -carotene when compared to untransformed control (1.2 to 5.4 $\mu\text{g/g}$).

Establishment of screening facility for iron and zinc bioavailability

A state-of-the art facility for screening iron, zinc and β -carotene bioavailability using simulated in vitro digestion/Caco-2 cell model have been developed in NIN. The facility is now ready for taking up screening of micronutrient bioavailability from bio fortified rice, wheat and maize for its selection and breeding.

Accelerated Crop Improvement Programme

Department launched a major translational project on crop improvement where molecular markers already available in public domain for important agronomic traits in wheat, rice, soybean, chickpea and maize have been validated and are being

introgressed in the high yielding cultivated varieties suitable to specific agroclimatic zones and also at all India basis by pyramiding genes through Marker Aided Breeding (MAB). The various biotic stress traits being undertaken in wheat are Leaf rust, Strip rust, Stem rust, Brown and Yellow rust. Varieties of both *Triticum* (17 varieties) and *Durum* wheat (2 varieties) are being targeted and efforts are being made to bring resistance to almost all races of these rust prevalent in the country by pyramiding these genes. Similarly quality traits of wheat namely, high grain protein content (HGPC), low amylose content, high gluten strength and grain hardness in 13 *Triticum* varieties and HGPC, high yellow pigment content and lipoxynase activity in two *Durum* varieties are being brought through MAB.

In rice 14 varieties for traits like Bacterial leaf blight (5 genes), Blast (5 genes), Gall midge (3 genes) and Brown plant hopper (3 genes); 3 varieties for salt resistance (*Saltol* gene), 4 varieties for submergence tolerance (*Sub 1* gene), 5 varieties of chickpea for resistance against *Ascochyta* blight (prevalent races) and *Fusarium* wilt (2 races); 5 varieties of soybean for kunitz trypsin inhibitor and rapid conversion of 8 hybrids into Quality Protein Maize are being developed by pyramiding genes mentioned above. At the time of project completion, about 45 high yielding varieties of wheat, rice, soyabean

and chickpea; and 8 QPM hybrids will be in final stage of development. Forty one centres are participating under this programme.

SAUs Programme Support

The Department extended programme support for R&D in agricultural biotechnology to four state agricultural universities. Highlights of their achievements are as follows:

UAS, Dharwad

Three transgenic pigeon pea events carrying *Cry1Ac* gene for pod borer resistance have been selected based on repeated insect bioassay results and southern hybridization data. Currently these events are being characterized for expression levels of target protein in leaf, flower and tender pods.

Four different genes coding for chitinase 3 genes for endoglucanase were cloned from *Trichoderma* and expressed in yeast. Isolates of *B. thuringiensis* with 100% toxicity at end of 48 hours on *Plutella xylostella* have been identified. Mutants of *cry1Ac* and *cry1AcM* have been developed. Two mutants showed enhanced mortality (10 and 20% more than original *cry1Ac*). A more efficient *Agrobacterium*-mediated transformation method to transform tomato cultivars, Pusa Ruby and DMT2 has been developed.

Transformation of native and codon optimized (synthetic) *cry1Ac* to tomato plants was attempted and the plants are at various stages of development.

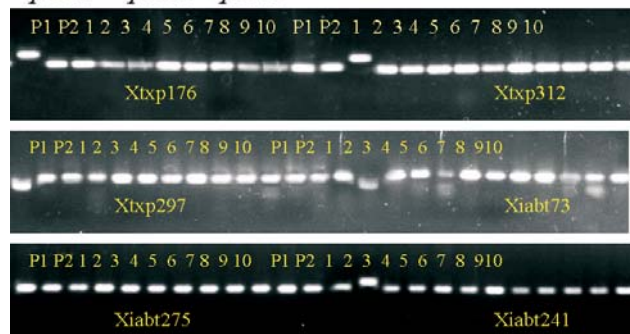
In sorghum BC₃F₃ homozygous Near Isogenic Lines (NILs) carrying different combinations of charcoal rot (CR) resistant *qCR1*, *qCR2* and *qCR3* QTLs from E36-1 in the background of M35-1 and SPV86 were field evaluated and found to be resistant to the disease. These varieties carrying all the three QTLs, together with other combinations are being multiplied in the field for station trials and large-scale field demonstrations. Three stable QTLs for stay green, one for water use efficiency and ten other drought and yield related traits in sorghum were also mapped. M35-1, SPV86 and SPV570 were rabi varieties introgressed with these QTLs. The BC₃F₃ NILs carrying different combination of QTLs are currently (*rabi* 2011-12) being field evaluated.

A set of 17 advanced breeding lines of Pigeon Pea developed through MAS for resistance to *Fusarium* wilt and another set of 41 additional progenies selected based on DNA markers (SCAR) linked to recessive allele of a *Fusarium* wilt resistant gene from F₅ generation population derived from various combination of parents were field evaluated and the superior lines will be forwarded to further evaluations and selections to include into multi location trails.

In pigeonpea, one mapping population each for *Fusarium* wilt-GS1 × ICPL8863 and SMD-ICPL8863 × BSMR 736 were forwarded to F₆ generation. The subsets of RILs were subjected to SSR markers segregation testing and they were found to be segregating into expected 1:1 ratio. Currently the F₇ seeds from selfed individual RIL are being harvested from field.

Maize *Ac* and *Ds* transposons were used for generating tagged mutants in M 35-1, a popular *rabi* genotype of sorghum for its functional genomics. One mutagenic plant and one *Ds*-tagged mutant was obtained with transiently expressed transposase system. In addition, 4 plants with transposed *Ds* containing *iAc* were obtained.

qCR1 + qCR2 + qCR3



Conformation of homozygosity of QTLs with different combination in BC₃F₃ progenies in SPV86 background



Seed multiplication of CR resistant QTLs introgressed M35-1 and SPV 86 -*rabi*-2011-12

Fig. 4.1



Fig.4.2: BC₂F₃ population derived from crosses with *Ae. speltooides* in the field

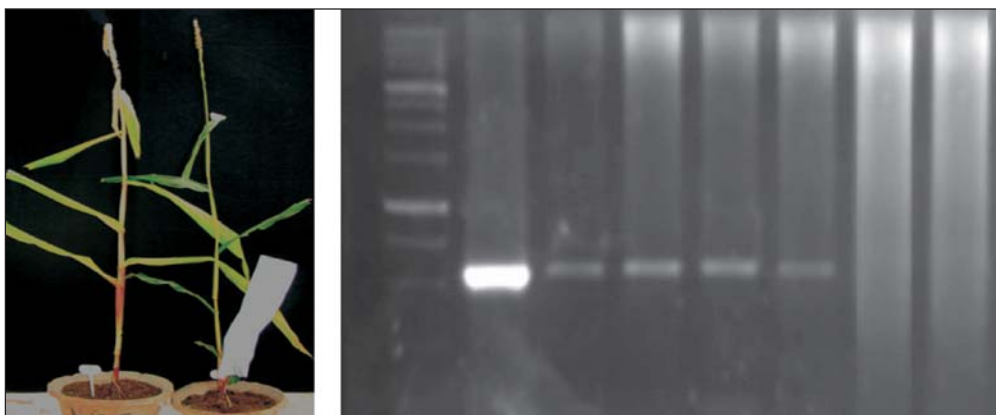
PAU, Ludhiana

As part of effort to develop heat tolerance in wheat, a linkage map has been generated from C306 X PBW534 with SSR markers. Various components of heat tolerance are being mapped onto this linkage map. In addition, introgression profiling of *T. durum*- *ae speltooides* is being done to develop a panel of chromosomal segment substitution lines (CSSL) of *ae. speltooides* in *T. durum* background.

In rice to enhance water use efficiency, the generated RIL population has been evaluated

for various traits suited to direct seeding and for yield and yield components. Some high yielding lines have been identified for testing in replicated multi-location trials. These RIL populations are being further analyzed for mapping QTLs associated with yield and yield component traits suited to aerobic conditions. For developing resistance to stem borer and tolerance to abiotic stresses, *ZAT12* and *Cry1Ac* genes have been introduced into maize inbred LM5 and LM13, respectively, through particle bombardment using immature embryos and confirmed through PCR.

Fig.4.3 : Transgenics of maize confirmed through PCR



The glyoxalase gene (*Gly I*) to induce salinity tolerance is being used for rough lemon transformation. Protocols have been developed for direct regeneration of plants from cultured epicotyl segments and factors affecting success of biolistics based transformation have been standardized.

TNAU, Coimbatore

A reproducible genetic transformation protocol has been standardized for hill Banana ecotype 'Virupakshi' and 25 putative transgenic hill banana plant lines have been developed exhibiting resistance against Banana Bunchy Top Virus (BBTV), which are being maintained in the transgenic green house. An interspecific mapping population was developed between mung bean (*Vigna radiate* Wilzck) and rice bean (*V. umbellata*) and an introgression line VGG RU 1 was identified to exhibit complete resistance against MYMV.

In rice a QTL near RM8085 on chromosome 1 linked to grain yield under drought stress explaining 11.8, 14.7 and 20.9 per cent phenotypic variation in 3 different trials has been identified. Preliminary QTL analysis in cotton led to identify several QTLs including two major QTLs on chromosome 19 and 25 for fiber quality traits across the mapping populations and genetic backgrounds. In rice, NILs introgressed with QTLs associated with root traits have been developed, and also identified proteins cosegregating with root penetration ability have been identified. Drought tolerant rice lines developed through MAS are under evaluation.

Low Phytate maize inbreds are in the advanced stage of backcrossing. In addition, transformation protocol for tropical maize has been standardized and gene encoding for *Phytase* is being used for developing transgenic maize lines.



Transgenic hill banana plants maintained in net house

Fig. 4.4

GBPUAT, Pantnagar

Under the programme, utilizing *Arabidopsis thaliana* as model plant, it was observed that MAPK 3 plays a role of prime importance during *Alternaria* pathogenesis process. It's full length gene was isolated and cloned from *Brassica* for development of knockout as well as over expression in *Brassica*. In rice, unique markers associated with salt tolerance were identified which can be used for breeding salt tolerance. In order to identify genes for blast resistance, four lines showing blast resistance were selected as donor parents and crossed with traditional varieties. Chi-square analysis of the segregation data showed that a major dominant gene was conferring resistance to blast and was segregating in a Mendelian fashion.

A full-length gene sequence of a class of calcium sensor in plants known as

calmodulin 'CaM' was isolated from finger millet that highly expresses during the grain filling stages suggesting that it might be involved in the activation of CaM dependant calcium ATPase transporter that pumps the calcium during grain filling.

In silico experiments identified a key antioxidant enzyme, namely *apx1*, that has further been characterized and fully length gene isolated and cloned. One novel drought inducible gene 'IDIP' (Important Drought Inducible Protein) has also been identified.

Network project on development and evaluation of salt and drought tolerant transgenic rice

This project is aimed at the development of salt and drought tolerant "marker-free" rice. For this, fusion gene containing both

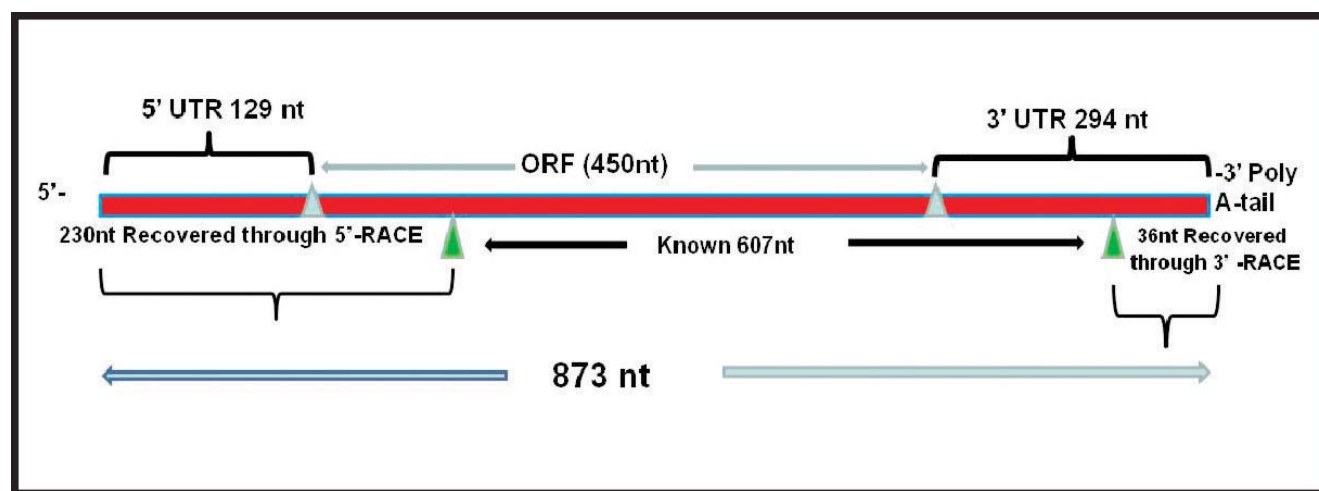


Fig. 4.5 : Molecular cloning of full length Calmodulin 'CaM' gene from Finger millet

trehalose-6-phosphate synthase (TPS) and trehalose-6-phosphate phosphatase (TPP) together was over expressed in a salt sensitive rice variety, IR64 at ICGEB, New Delhi and DRR, Hyderabad. Four independent transgenic events that were southern positive and showed enhanced salt tolerance were transferred to the Central Soil Salinity Research Institute (CSSRI), Karnal for further testing under saline and sodic soil conditions. Preliminary observations suggested that overexpression of trehalose biosynthesis genes confers enhanced

tolerance towards salinity and sodic stress in transgenic IR64 rice. Screening of these lines for the next two generations under normal, saline and sodic conditions at CSSRI, Karnal, revealed that some of these lines are promising in terms of early vigour, spikelet fertility and overall yield than the control non-transformed IR64 and the best local check for salinity and sodicity.

The investigators are now seeking RCGM permission to conduct strip trials of these transgenic lines.

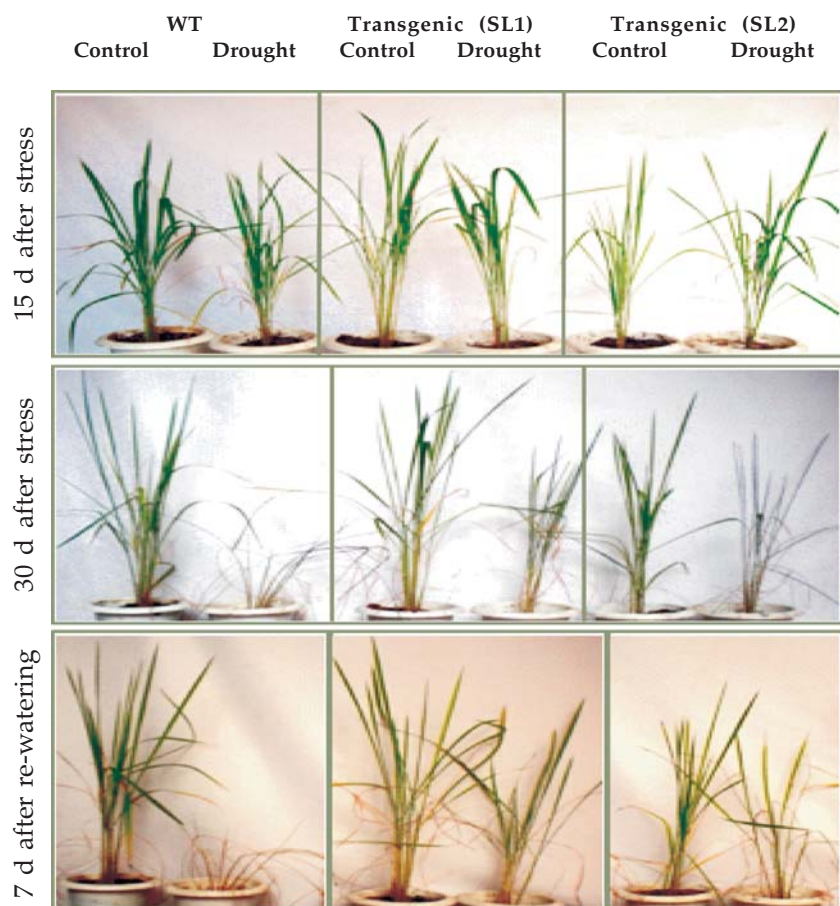


Fig.4.6 : Evaluation of drought stress tolerance of TPSP transgenic IR64 rice vs WT IR64 rice at the vegetative stage carried out at ICGEB, New Delhi.

DBT-IRRI Project

From QTL to Variety: Marker Assisted Breeding of abiotic stress tolerant Rice varieties with major QTLs for drought, submergence and salt tolerance

The project has been initiated for transferring major genes/QTLs for drought, submergence and salt tolerance into popular Indian rice varieties through marker-assisted backcross breeding (MABB). The network involves fifteen Indian institutions, including ICAR Institutes, State Agricultural Universities and Central Universities with NRCPB, New Delhi being the lead centre. The main objectives of the project are: (i) improved varieties of rice tolerant to drought, submergence and salinity, (ii) advance breeding lines of rice with these traits, (iii) trained human resource for MABB; and (iv) information generation on markers for the QTLs and their validation in the recipient rice cultivars and genotyping. The project envisages to improve at least 12 popular rice varieties grown in the rainfed agri-eco systems within the country through marker-assisted backcross breeding for flood, drought and salt tolerance.

Challenge Programme on Chickpea Genomics

At NIPGR, New Delhi, nuclear genome of

chickpea ICC4958 is being sequenced. The SOLiD platform was used for sequencing of ICC4958 as well as the wild variety *C. reticulatum* PI489777 (parent of the mapping population) and used to identify unique SNPs. About 4000 SNPs have been selected and are being genotyped for generating a high density linkage map of chickpea. Additionally, 2000 SSR markers polymorphic between the parents have also been identified for mapping. Simultaneously, deep sequencing of the chickpea transcriptome has been done using both the short and long read NGS platforms and assembled into 34,760 tentative consensus (TC) transcripts representing 35.5 Mb of the sequence. These have been functionally annotated and identification of new genes, analysis of gene families and gene content has been done. The analysis of abundance of chickpea transcripts within a tissue sample led to the identification of differential and tissue-specific transcripts. Moreover, 4,111 SSRs have been identified. The chickpea transcriptome has been published and made publicly available through the development of the Chickpea Transcriptome Database and transfer to the industry for the development of "Chickpea Expression Microarray". The whole Genome Browser for chickpea is under development, currently using one of the largest available contigs of the nuclear

genome and contains the following tracks: Gene (Overview), GC content (Region), and CDS, Exon, Intron, 5'UTR, 3'UTR, Complex Repeats, tRNA, and Translation.

For manipulation of root architecture to improve abiotic stress tolerance, a putative CBL-interacting protein kinase (CIPK/sos2-like protein kinase, PKS) was identified. The roots of the T1 seedlings were found longer than the vector-control seeds.

Functional analysis of inositol biosynthetic genes is being done for which homozygous *Arabidopsis* transformed lines for each gene (*CaMIPS1* & 2) were generated and growth patterns under saline environment were analyzed.

The water-deficit stress responsive proteome of chickpea was analysed which led to the identification of 773 proteins.

Of these, 104 annotated proteins matched with *Arabidopsis* and 75 with rice, while most other proteins were found in different legumes [*C. arietinum* (91), *Medicago* (131), *G. max* (27), and *P. sativum* (42)]. Further, 103 membrane associated proteins were identified from the membrane proteome.

Transcriptome sequencing of chickpea plants, inoculated with *Ascochyta rabiei* was done using the Roche 454 platform. The data was assembled to generate 68,942 unigenes, with average contig length of 747 bp, N50 of 963 bp.

To unravel the molecular events at various stages of seed development and its nutritional status, transcriptome sequencing of developing chickpea seeds at various stages (10, 20, 30, and 40 DAA) was carried out using the Roche/454 platform.

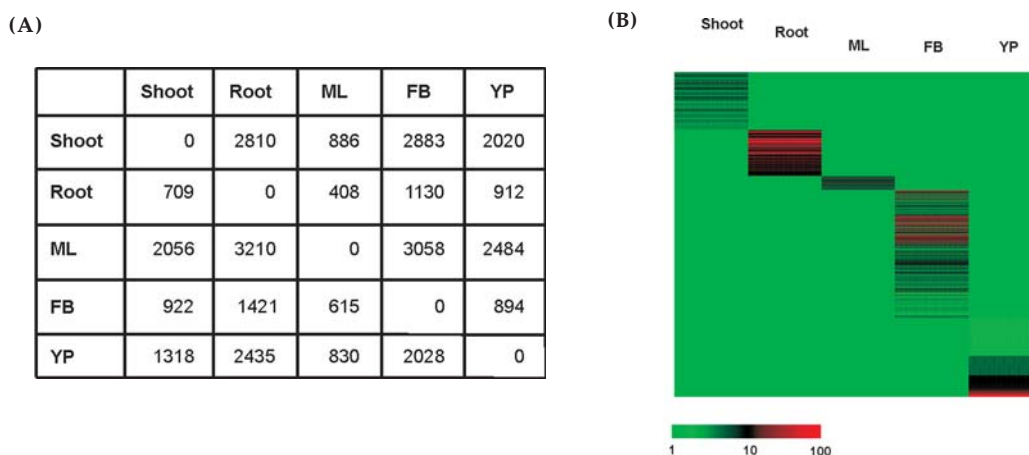


Fig. 4.7: Differential and tissue specific expression analysis of chickpea transcriptome. (A) Transcripts preferentially expressed in each tissue sample as compared to others in tissue by tissue comparison. For the transcripts in each cell, there is preferential expression in the column tissue than the row tissue sample. (B) Heatmap of the transcripts preferentially expressed in various tissue samples. The color scale (1100) represents RPM value. ML, mature leaf; FB, flower bud; YP, young pod.

Functional annotation was done and contigs were categorized as biological process, cellular component and molecular function. Molecular analysis of important families is in progress. Currently, the development of comparative seed cytosolic proteome is in progress.

National Plant Gene Repository

The Department has set up a National Plant Gene Repository (NAPGER) at National Institute of Plant Genome Research, New Delhi. It is a National facility for (i) storage and distribution of plant genes, promoters and ESTs in form of DNA clone, library, etc. and (ii) to develop a database for all stocks and other information. The institute has procured the necessary equipments, created infrastructure for setting up the facility and also recruited the sanctioned manpower. The research protocols to be followed in NAPGER have been developed. A web page has been developed and shortly an advertisement would be issued to publicize the NAPGER activities so that large section of scientific community is aware of it and gets benefitted.

Biofertiliser Biotechnology

The Department has supported programmes

for developing various bio-fertilizers and technology packages for their mass production and also focused on conversion of industrial agricultural wastes into biomanure and manage the organic waste resources using low capital input protocols without expensive laboratories and sophisticated industrial instruments.

Microbial Consortia

Jaypee Institute of Information Technology, Noida project studied plant growth promoting microbes with Biofertilizer and bio control properties to build a consortium comprising both bacterial and fungi *spp*. Sampling of microbes was done from the rhizosphere of different plant sp. such as banana, sorghum, millets, pumpkin, potato and grasses. Isolates collected from the rhizosphere of sorghum and grasses were particularly interesting as they were not only withstanding high pH, but also showing tolerance to temperatures in upper mesophilic range of 35-40°C. The antagonistic effects were confirmed to develop a consortium.

Manipur University also developed microbial consortia for the effective formulation of optimal strains of plant growth promotion in rice and bio control against rice fungal and bacterial pathogens. *Actinomycete*, *Bacillus* and

Pseudomonas sp were the focus of the study. After screening of the best strains in lab/greenhouse test, individual or mixtures of strains were subjected to single or multi-site pot/field studies to learn feasibility for deployment of consortia of beneficial microorganism for rice. Four isolates were identified. The culture filtrates did not show any inhibition against the fungal pathogens. In *in vitro* seed germination (vigor index) test was performed for three of the selected strains.

Vermicomposting

Timber lignocellulosic wastes were inoculated with different combinations of the fungi *Phanerochete chrysosporium*, *Trichoderma reesei*, *Aspergillus niger* and the bacteria *Azotobacter chroococcum*. Out of 10 microbial combinations tested for pre-decomposition, the combination of *P.chrysosporium* + *T.reesei* was found best in terms of lingo-cellulosic degradation prior to vermicomposting. The feasibility of bioreactive timber solid waste vermicompost (TSWV) had also been validated for the first time.



Fig 4.8: View of vermi- entrepreneur using wood wastes as substrates

Formulation of *Mycorrhiza* and Agriculturally Important Micro-organisms (AIMs)

The Energy Resources Institute (TERI), New Delhi revalidated the PGP/BCA strains such as *actinomycete* isolates LSCh-10C, NRPI-18 and NRPI-18 and NRPI-26 and putative *Bacillus* isolate CHDR. They established the co-habitation of AIMs with Arbuscular Mycorrhizal Fungi (AMF) to synergies their beneficial effects by developing a single bio-inoculants product that can improve plant growth by supplementing with nutrients. Six new unculturable endobacterial sequences were detected by the DGGE analysis and 5 more after cloning of 16S product directly. Endobacterial diversity comprised both *Bacillus* related species as well as bacterium-like organisms (BLOs).

In case of termicomposting, Pondicherry University, Pondicherry has completed the systematic survey of termite species with the species available and there relative abundance has been established. Two types of multi-compartment termireactors designed. The multiple compartments would enable to use different substances simultaneously at each location and see the relative preference of termites at that location for different feeds. Study has been undertaken towards captive colony development and preliminary designs of

alate traps, *in situ* termireactors, and termite harvesters. Pondicherry University had set up an interactive web-based repository of all the information and the resources of information on termites-systematic, distributions, niche, habitat, biology, substrate preference, role in natural environments, control methods etc.

Biopesticides and Crop Management

A number of research projects have been supported in the highly specific area for the control of pests and diseases of economically important crops, thereby enhancing the agricultural productivity for sustainable development. Highlights of some of the project achievements are as follows:

Microbial Pesticides and Natural Enemies

At NCL, Pune Enzymes from a killed fungus (*Myrothecium verrucaria*) and conidial preparation of entomopathogenic fungi (*Metarhizium anisopliae*, *Beauveria bassiana* and *Verticillium lecanii*) were produced in the laboratory to control mealy bug for 2 consecutive years (2009-2010 and 2010-2011). In addition to the control of mealybug (50-75%), *M. verrucaria* formulated enzyme preparation reduced the infection level of

downy mildew (*Plasmopara viticola*) and powdery mildew (*Uncinula necator*) by 71% and 76%, respectively in grapes. At Kuvempu University, Karnataka Survey of Pest incidence as well as egg parasitoid on *Cylopelta siccifolia* was completed. Laboratory experiment were carried out to know about the hatchability and surveillances of *C. siccifolia*. Aggregation and separation behavioral study of *C. cissifolia* will be done in the field.

Data on compatibility of nematophagous fungi *Paecilomyces lilacinus* and antagonistic bacterium *Pseudomonas fluorescens* with AM fungus (*Glomus bagyaraje*) was developed *in vitro* and *in vivo* at IIHR, Bangalore. A strategy of management of wilt disease complex in tomato and capsicum using *P. fluorescens* and *P. lilacinus* with AM fungus

(*Glomus bagyaraje*) was developed. Data on compatibility of nematophagous fungi *Pochonia chlamydosporia* and antagonistic bacterium *Pseudomonas fluorescens* with AM fungus (*Glomus bagyaraje*) was developed *in vitro* and *in vivo*. Again at IIHR, Bangalore a strategy was developed for the management of disease complex in capsicum, okra, carrot, papaya, banana, gladioli and gerbera. Protocol of mass production of combination formulations of *Pseudomonas fluorescens* with *Paecilomyces lilacinus* and *Pseudomonas fluorescens* with *Pochonia chlamydosporia* was standardized. Strategy of enrichment of vermicompost or neem cake for the application in the main field was also developed. Toxicological data, shelf life data and bio-efficacy data of bio-pesticide formulations was also generated.

A



C



B



Fig. 4.9: A. Evaluation of bio-efficacy in gerbera under farmers field conditions being verified by member DBT task force along with the beneficiary farmer, B. Distribution of bio-pesticides to the farmers for field evaluation of bio-efficacy and C. Evaluation of bio-efficacy on Papaya under farmers field conditions

Under tulticentre project implemented at IARI, Pasighat and Mysore soil, plant and seed samples were collected from different locations of Pasighat (Arunachal Pradesh) and North India after recurrent field surveys. A total of 97 isolates of PGPR were taken up for further characterization. A set of isolates were screened against seed borne pathogens of cabbage, cauliflower and chilli from North east (Pasighat). Based on multiple screening, four isolates for tomato and six isolates for cabbage were observed to be beneficial in better germination and seedling vigor. After a sequence of screening in laboratory and pot culture, four best strains were identified and are being tested for seedling priming under field conditions. Best strains were given to Pasighat for further evaluation and Mysore centre for molecular characterization. In Pasighat centre, the best strains received from IARI are being evaluated under pot culture and field. Citrus seedlings were also raised to test PGPR. The collaborating centre at Mysore has completed the biochemical tests and

confirmed the cultures belong to *Pseudomonas* and *Bacillus* group.

Botanical Pesticides

Study at Manonmanium Sundaranar University, Tamil Nadu studies were carried out for understanding the within-plant preference in the rice leaffolder (RLF), *Cnaphalocrocis medinalis* (Guenée) ((Lepidoptera: Pyralidae) and its consequences for offspring performance on the host-plant *Oryza sativa* L. (TN, Ambai16, and IR20 varieties) concerning the role of induced resistance of rice plants to RLF feeding. The present study examined the effects of induced resistance on the feeding (food assimilation and digestion) in green house and also the field cages. This study also observed *C. medinalis* food utilization, in order to estimate the possible influence of induced resistance on *C. medinalis* feeding behavior. These results indicate that JA application induces systemic defenses in rice that have a direct negative impact on *C. medinalis* survival.

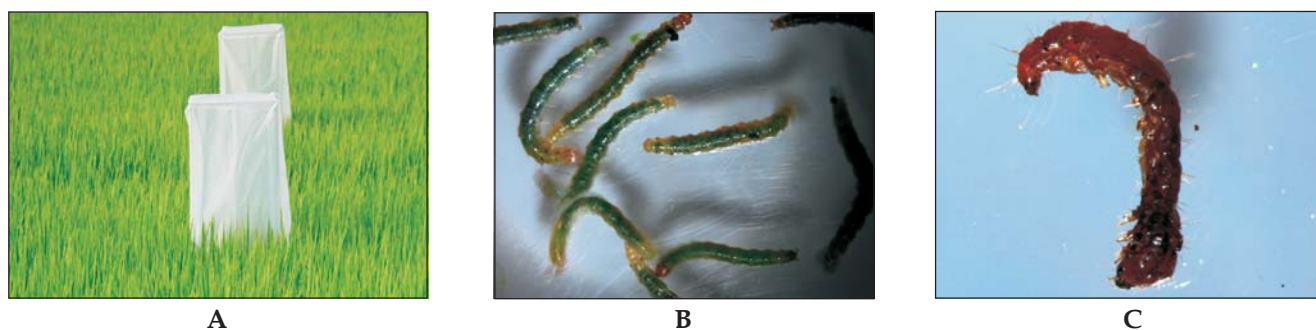


Fig. 4.10: A. Field Cages, B. Rice leaffolder culture C. Effect of JA on rice leaffolder larvae (3 Mm)

Entomopathogenic Nematodes (EPN)

At TFRI, Jabalpur seven native isolates (TFRIEPN-08, TFRIEPN-15, TFRIEPN-23, TFRIEPN-49, TFRIEPN-50, TFRIEPN-56 and TFRIEPN-57) from banana, mango and two known isolates (*Heterorhabditis indica* and *Steinernema carpocapsae*) were maintained round the year. Laboratory culture of fictitious host waxmoth, *Galleria mellonella* was maintained round the year, so as to obtain 300 mature larvae per day. The white grubs and their adults of three species (*Holotrichia rustica*, *H. mucida* and *H. consanguinea*) were collected from the forest nurseries from central India. Field evaluation of the native EPN isolates was initiated in the institute campus and in the selected termite mounds in the teak plantation areas. Experiments for bioefficacy of native species/ strains TFRIEPN-23, TFRIEPN-49 and TFRIEPN-50 were carried out against white grub species, *Holotrichia rustica*, *H. mucida* and *H. consanguinea* in laboratory.

Molecular Studies on Biocontrol Agents

At S V University, Tirupati, the JHEH gene was amplified, cloned and sequenced. A ~800 bp sequence of Bihar hairy caterpillar JHEH was obtained and analysed. This partial JHEH sequence was found to have homology with other lepidopteron JHEH's.

At TNAU, Coimbatore the survey was conducted under different agroclimatic zones comprising major Mango and Banana growing areas and markets of Tamil Nadu. Polyclonal antibody produced against 40 and 65 kDa mycelial protein exhibited the specific reaction with *C. gloeosporioides* and *C. musae* isolates respectively. By utilizing these PCA, presence of latent infection was detected both *in vitro* and *in vivo*. RAPD-PCR technique was utilized to determine the per cent similarity between the isolates of the pathogen. The SCAR primers were able to detect the pathogen in fruit peel tissue at 30 ng of infected DNA tissues.

The crude extracts prepared from three common cultivars, three wild relatives (ICP 15774, ICP 15815 & ICP 15868) and thirteen wild accessions (ICPW 60 to ICPW 72) of pigeonpea were tested for their proteinase inhibitory (PI) activity against bovine trypsin, chymotrypsin and midgut trypsin-like proteinases of the following lepidopteran insects: *Helicoverpa armigera*, *Achaea janata*, *Spodoptera litura*, *Papilio demoleus*, *Amasacta albistriga* and *Daphnis nerii*. All the varieties of pigeon pea chosen in the present study possessed both trypsin inhibitory (TI) and chymotrypsin inhibitory (CI) activity. The trypsin-like proteinase inhibitory activity of two wild relatives ICP 15815 and ICP 15868 were found to be highest in the following order: *A. janata* (>

800 AJTI units), *H. armigera* (> 500 HATI units), *A. albistriga* (> 35 AATI units) and *P. demoleus* (< 10 PDTI units).

Development of comprehensive website on bio-pesticide

A comprehensive website on “Bio-pesticides” has been developed. Salient achievements compiled from more than 250 completed projects have been included which will benefit scientists, entrepreneurs and farmers. The website is under security check in NIC.

Bioresource Development and Utilization

The National Bioresource Development Board (NBDB) accelerated R&D using modern tools of biosciences for development of new products and processes utilizing the rich biodiversity of our country.

Bioprospecting and product development

Mission programme on microbial prospecting: drugs from microbes – a public private partnership

A Mission programme was launched in the year September, 2007 which involved partnership of 9 National Institutes & Universities alongwith Piramal Life Sciences

Ltd., (PLSL) as an Industry Partner in a unique public-private partnership model. This program has contributed to the collection of microbes from different biodiversity from all over India (the Western Ghats, North East, mangrove, marine environment, polluted sites etc.). The largest collections of microbial cultures (nearly 2,50,000) were screened for four different therapeutic targets. A total of 16123 three stars hits were obtained of which 518 anti cancer, 3643 anti inflammation, 6676 anti diabetic and 5286 were anti infective activities. These potent cultures selected in the above exercise are being used to generate the list of 1000 cultures to be taken in the next phase of the program for identification of novel drug scaffolds.

In Phase II activity i. e. chemical characterization of selected hits of bioactives, randomly selected 150 extracts were prepared and analyzed for chemical characterization. Additional 150 extracts have been prepared; analysis is in process and taxonomically diverse bacteria based on ~4000, 16S rDNA sequences have been generated. UPLC analysis and the dendrogram were obtained by identifying similar clusters of the chemical fingerprinting analysis.

Action was initiated to explore the microbes for many other biotechnologically useful

products of industrial importance such as production of industrially important enzymes (i.e. Adenosine deaminases, nitrile hydratases, hydantionase, nitrilases), screening for extracellular protease activity for commercial purpose and identification of PKS genes from mangrove microbes etc.

Microbial Culture Collection Centre

The Microbial Culture Collection center (MCC) established at the National Centre for Cell Science (NCCS), Pune by the Department of Biotechnology as the largest culture collection is now an affiliate member of the WFCC and is registered with the WDCM. The MCC was recognized by the WIPO Geneva as an IDA in April 2011. Currently, it holds greater than 2 lakh cultures under various categories, such as normal, three-star, re-fermented, scale-up and have been categorized based on the degree of bioactive properties shown by them against cancer, diabetes, inflammation and infection. Majority have been tentatively identified based on partial rRNA gene sequencing. MCC has launched its own website housed on the NCCS webpage. MCC has begun to provide services to academic and industrial establishments for microbial identification. The information of the molecular finger printing of the cultures has been added to the database. In the 12th plan it is proposed that the Microbial

Repository would be set up as an independent Autonomous Institute for Microbial Culture Sciences and Research and provide highest-standard services with focused research on microbial ecology and systematics.

Prospecting of genes and molecules for product development

Projects have been supported for prospecting of novel genes, molecules, enzymes etc. from plants, microbes, fungi, lichens for production of potential products of industrial importance. Novel genes/promoters, transcription factors were identified to develop transgenics for biotic/abiotic stress and for understanding different metabolic engineering pathway(s) operative in a system. Some of the technologies and products developed from projects and important leads are mentioned below:-

- In a programme aimed to prospect plant and insect resources of the Western Ghats for important metabolites, promising species from *Icacinaeae* shown to produce high camptothecin have been undertaken for domestication. Alternate sources of shikimic acid from plants of the Western Ghats have been identified and spatially mapped. Among the angiosperms, only two or three plants *Calophyllum apetalum* had the

highest level of shikimic acid. Gymnosperms species evaluated had detectable levels of shikimic acid. One of the species belonging to the araucariaceae family yielded the highest levels of shikimic acid (5.02%). Isolation of anti-microbials from crude extracts of insect systems from the Western Ghats has been carried out (Fig. 4.11).

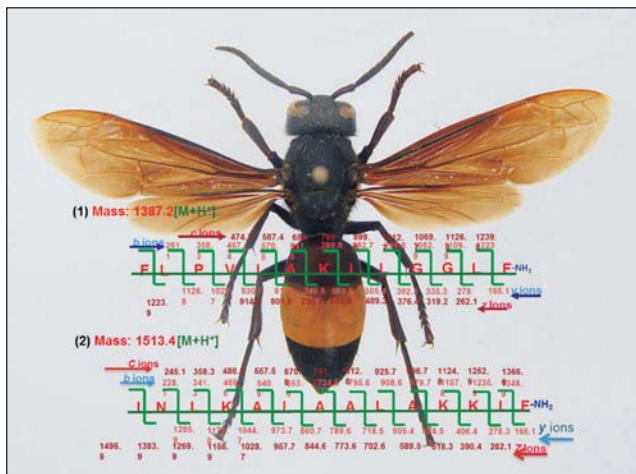


Fig. 4.11: Anti-microbial peptides from wasp venom

- A network project with eight institutions was initiated to bio-prospect for novel bioactive molecules from forest resources of the country. Populations of *Dysoxylum binectariferum* have been identified in Western Ghats and their distribution mapped. Significant variation in rohitukine have been obtained (0.15% to 7.62%) and derivitization of rohitukine and bioactivity against anti-malarial CDK's in progress. Similarly, variation in

corosolic acid has been established in *Lagerstroemia speciosa* and studies are underway to evaluate the plant extracts for anti-diabetic activity. Plant extracts of *Saraca asoca* are being evaluated for their anti-inflammatory activity. Microsatellite markers have been successfully developed and primers are being designed to undertake population genetic study.

- In a programme aimed at Bioprospecting of selected lichen and plant species for product development against cancer and tuberculosis, MSSRF has isolated four novel compounds from lichen species (Fig. 4.12).

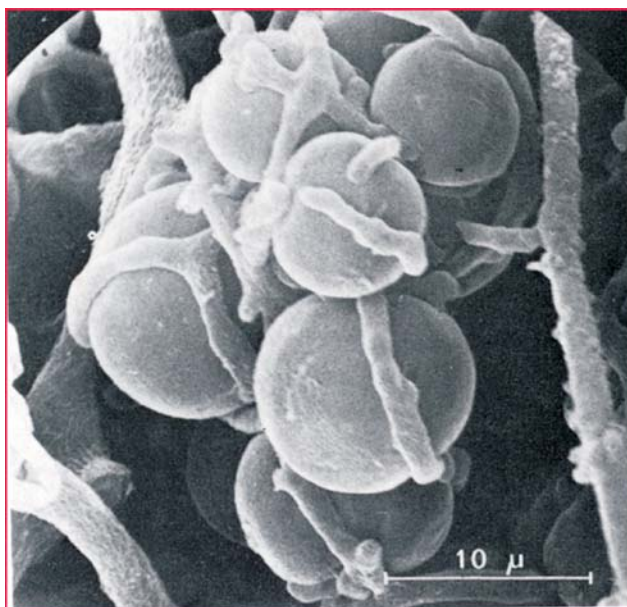


Fig. 4.12: Ultra - structure of Lichen thallus- Secondary compounds - deposited on the hyphal wall

- A biopesticide formulation (Bollcure) developed under DBT support from

Eucalyptus has been transferred to two industries. Central Insecticide Board has approved the registration of “TERI-DBT Bollcure” for commercialization across the India. Bollcure is environment friendly, suitable for both organic and IPM crop practices, suitable for conventional as well as Bt cotton, cost benefit ratio for cotton in 1:4.15 , cost benefit ratio for chickpea in 1:17.1.

- Under studies on cold tolerant strains profile of the tolerance of altogether 10 cold-tolerant strains and 4 mesophilic strains to various environmental stress factors (viz, high temperature, freezing, high salt, high and low pH, oxidative stress, UV-radiation) were obtained. Remarkable variation was observed in the stress-tolerance of cold-tolerant strains, obtained from the same environmental niche of Antarctica and also between the stress-tolerance of the mesophilic and Antarctic strains
- Five *Muscodor* species have been isolated from stem internal tissue of the plant *Cinnamomum malabaricum*, *C.camphora* and from leaf of *Aegle marmelos* collected from Western Ghats and North Eastern Himalayas. Patent Application has been submitted on the new species of *Muscodor* with

mycofumigation potential and collaboration for product development is being finalized with Pest Control India Ltd. using the indigenous *Muscodor* spp.

- Under the project on mapping of marine green sulfur bacteria of India, eighty one samples from marine habitats of Goa and Gujarat were analyzed for genetic culture and diversity of green sulfur bacteria.

Characterization and Digitized Inventorization

Indian Bioresource Information Network (IBIN) portal

The IBIN was approved for Spatial Node, *Jeeva Manchitra* at NRSC, Hyderabad and Species node, *Jeeva sampada* at UAS, Bangalore. A set of six laboratories which linked their databases with the IBIN have been identified as BRICs of IBIN. The entire spatial and non-spatial data and also other related primary and secondary data is being hosted on a special portal Indian Bioresource Information Network. At IIRS Dehradun/ NRSC, Hyderabad, national seamless database of vegetarian type map, biodiversity modeled outputs of fragmentation, disturbance index and biological richness at national level have been prepared.

Spatial Characterization

Biodiversity characterization studies through satellite remote sensing and geographic information system was completed under the DBT-DoS project in 3 phases covering nearly 84 % of forest area. In Deccan Peninsula, 589 plant species recorded by information collected from spatially explicit, GPS tagged 1725 field plant inventory plots and distribution and abundance information of 881 species in Rajasthan, 313 species in Gujarat and 103 species in Lakshadweep have been done.

Quantitative assessment of plant resources in hot-spots of the country

The programmes on mapping and quantitative assessments of geographic distribution and the population status of plant resources were completed for the hot spots- Western Ghats, Eastern Ghats and North Eastern and Eastern Himalayan Regions with significant achievements. A first ever systematic attempt has been made for quantitative assessment of plant resources of Andaman and Nicobar islands. Several layers of Andaman and Nicobar Islands such as boundary, roads, rivers, places, water bodies etc were digitized. Data inputting system was developed to load the data sheets from

different teams. This assessment has been done in a grid based manner and the data has been compiled in the form of database.

DNA Barcoding

DNA Barcoding programmes were supported for generating barcodes for species of plants, insects and animals. In DNA Barcoding of the birds, approximately 1200 samples of birds have been collected from various parts of India. DNA barcoding of 17 *Phyllanthus* species using the *psbA-trnH* region, 53 rattan species were successfully completed. A digital database of *Phyllanthus* and Rattans species was developed which includes a diagnostic key to the different *Phyllanthus* species alongside their respective bar codes.

Resource Based Network Programmes

Several programmes have been launched to screen, characterize and improve important resources. Some important resources and interventions made are as follows:

Honey Bee

Under the ongoing network programme in the Apiculture sector with focus on quality improvement, study of genetic diversity and

development of molecular markers in Indian bee species, multiplexing of shortlisted microsatellite markers has been standardized. Two new lures have been developed and effectiveness of these novel plants based as well as the pheromone based honeybee attractant formulations is being evaluated.

Seabuckthorn

Under the coordinated network project on germplasm characterisation of Seabuckthorn from different regions of the country, collection of accession continues from across the country. Overall 488 accessions of three *Hippophae* species spread across Himalayas, namely, *Hippophae rhamnoides*, *H. salicifolia* and *H. tibetiana* have been characterized morphologically for various descriptors and are being compiled for development of a descriptor database. Chemical characterization of *Hippophae* leaf and fruit samples is being undertaken.

Hippophae Germplasm Resource Centre has been established at Lahaul (HP) by IHBT, Palampur in collaboration with the Forest Department of HP.

Coffee

The thrust of the study was on developing

trait specific molecular markers, disease resistance, low caffeine varieties. A network project involving CCRI (Coffee Board), CCMB (Hyderabad), UAS (Bangalore), MKU (Madurai) and CFTRI (Mysore) was supported. A few stress responsive genes were cloned and validated for stress response.

Tea

Tea network was started with eight institutes for improvement of tea, taking Tea Board along in all the programmes with the institutes include, IHBT Palampur, TRA Jorhat, UPASI, Coimbatore, RRL Jorhat, NEHU Shillong, IIT Delhi, Delhi University and TERI, New Delhi. 1286 microsatellite primers were designed by sequencing of the positive clones derived from enriched genomic libraries and publicly available expressed sequence data in tea (Fig. 4.13). 622 of the identified microsatellite markers were successfully validated in selected tea accessions and related *Camellia* sps for their wider applicability. More than 3000 crosses were made for blister blight and drought resistance. 1058 mature seeds were germinated and these populations established at the nursery conditions. 644 F1 progenies derived from 32 different crosses were established in the field condition.

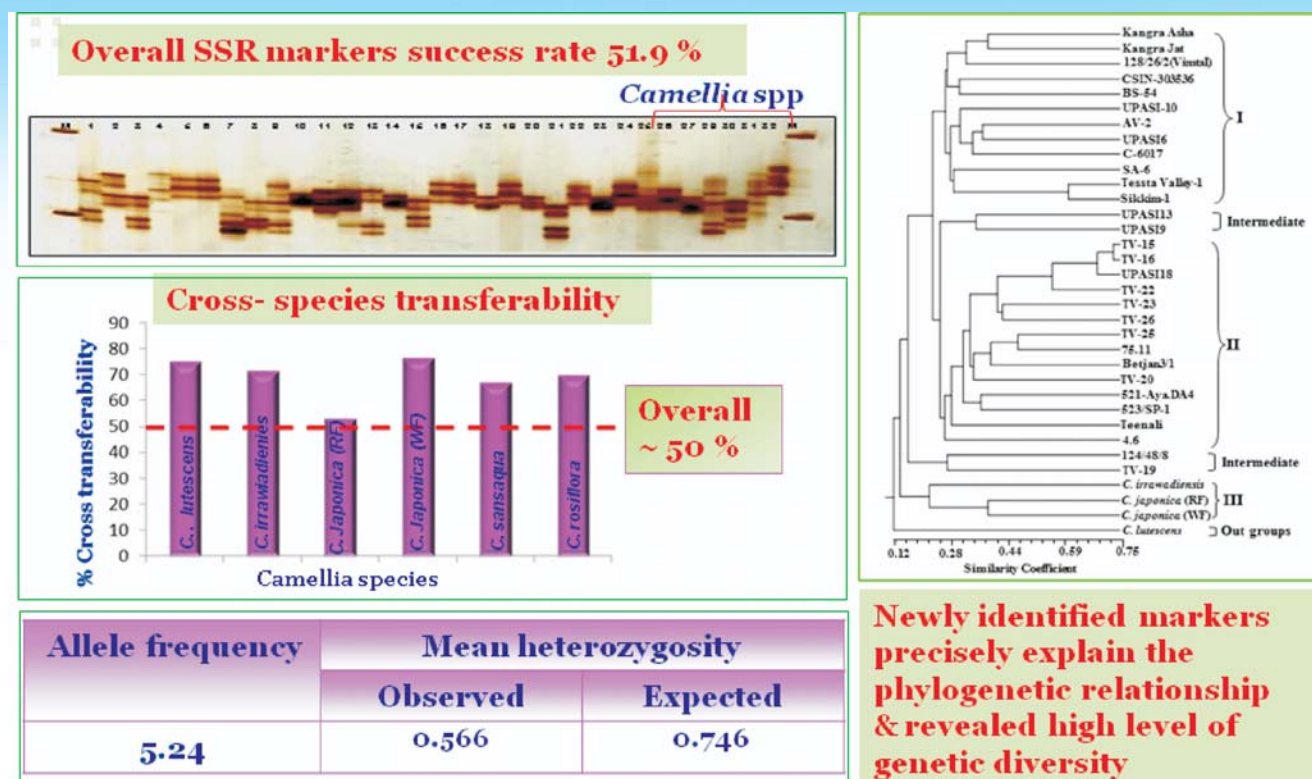


Fig. 4.13: Characteristics of microsatellite markers identified in tea

Zingiber

Multilocation trials for turmeric were completed in Sikkim, Assam, Meghalaya and Manipur. Technology for micro and mini rhizome production from ginger, turmeric and Kaempferia sp. has been optimized and transferred to AVS, Kottakkal for mass production for medicine manufacture. All the collected samples have been analyzed for their chemical compositions. The curcumin content of the collected turmeric varieties ranged from 1 to 11% and trans-geraniol content for collected varieties of ginger ranged from 23 to 36%. 1252 plantlets of ginger for *Nadia*

variety have been micro propagated. Micro rhizome induction has been observed in 266 plantlets and 150 are under primary hardening stage.

Sugarcane

The genomes of potyvirus isolates (SCMV & SStMV) infecting sugarcane and sorghum were partially sequenced. The full length genome of SStMV is determined and its genome organization and phylogenetic relationships were elucidated. Tissue culture protocols for development of somatic embryogenesis by different media combinations have been optimized.

Antibiotic sensitivity test was conducted to determine optimum concentration for selection of putative transplastomics using different antibiotics. 30 novel functional markers based on conserved intron scanning primers were developed for the first time, through the comparative analysis of publicly available expressed-sequence data of sugarcane, sorghum and barley and, the whole rice genome-sequence survey. 80 EST- SSR primers were synthesized based on the sequences available in public domain 103 genomic SSR (gSSR) primers were synthesized based on the sequences.

Gums and resins

The protocols were standardized for metabolite profiling of *C. wightii*. A range of chemically diverse metabolites including organic acids, fatty acids, amino acids, sugars and carbohydrates, sterols, cyclitols and terpenes were characterized using GC-MS. Most of the metabolites identified in this study are not reported earlier in *C. wightii*. Using high-field NMR spectroscopy 43 metabolites were identified from different plant parts of *C. wightii* which includes primary, secondary and intermediates of pathways. Some of the identified metabolites (other than guggulsterones) may have high commercial value. Germplasm of 78 accessions has been collected from different locations from *Commiphora* growing

regions (three different states viz. Haryana, Rajasthan and Gujarat) of the country.

Bamboo

Under the network program, 9 major states (Andhra Pradesh, Karnataka, Tamil Nadu, Gujarat, Himachal Pradesh, Uttaranchal, Kerala, Rajasthan and Haryana) and all the 7 states of North East were covered. Demonstration programme completed its tenure in 18 states covering 978 ha and efforts are being made to consolidate the performance data from all demonstration projects in the form of a booklet detailing a package of practices for Bamboo cultivation. Tissue culture/micro propagation technologies have also been developed at various R&D institutes for different species.

Capacity Building

DBT's Natural Resource Awareness Club

DBT Natural Resource Awareness Clubs (DNA Clubs) Program is aimed giving young school students (Class 6-12) a well rounded exposure to the fascinating world of bio-resources by implanting a suite of mutually complimenting set of activities that focus on various dimensions of bio-resources and seamlessly blend with formal school curriculums. DNA Clubs program is being implemented in 190 schools spread

across 20 States/UTs involving more than 11,400 student members each year. DNA Program has designated coordinator(s) nominated by the school management for each partner school. The RRAs are supported by a dedicated Program Management Unit set up by DBT for management of the programme.

DNA Clubs Program activities across 190 schools

S. No.	Activity (2010-11)	Number
1	Guest Lectures	745
2	Institutional Visits/ Field Trips	952
3	Audio Visual Shows	966
4	Laboratory Experiments	1828
5	Vacation Training Programs	18

DBT-TERI Mentoring Schools for North-East Region of India

The DNA clubs: DBT-TERI mentoring schools of northeast is being implemented through partner institutes in 361 high schools. Two days orientation for coordinating teacher has been completed for 7 northeastern states. 22650 students of Class

VI-X from 8 northeastern states are directly involved through 249 lectures, 830 experiments and hands on activities, 121 Audio Video shows, 160 field visits to different biodiversity rich areas and institutes of higher learning.

Rural Bioresource Complexes

The Department has established Rural Bio-resource Complexes to demonstrate viable and ecologically compatible technologies to the rural people for adoption in a holistic and sustainable manner. In the first phase, projects have been funded at five State Agricultural Universities (SAU). An independent study on the Impact assessment of Rural Bioresource Complexes in terms of its socio-economic benefits that have been transferred to the community was commissioned by DBT to Mott MacDonald Pvt. Ltd., Noida. The planned interventions of respective SAUs and the implemented interventions, as observed in field have been compared, which revealed that the number of activities have increased in almost all the institutes. Most of the institutes have conducted baseline study at the initial phase of the project. From this evaluation study it was found that the Bio-resource complexes have made major impact in extending certain recent interventions to the community and all the research institutes have done their work precisely. The Rural

Bio-resource complexes have initiated and popularized a progressive approach in integrated farming based livelihood generation.

Rural Bioresource Complex in North-East India at North-Eastern Hill University, Shillong

The Rural Bioresource Complex in North-East India at North-Eastern Hill University, Shillong has been established. Two institutions viz., North Eastern Hill University (NEHU) and ICAR Complex for N.E Hill Region are involved in implementing the project; ICAR is responsible for demonstration farming of Megha 1 turmeric and Khasi Mandarin, while the remaining activities of the project are the responsibility of NEHU. Collection and ex-situ vivo conservation of 32 Citrus varieties have been collected from Meghalaya. For extraction of turmeric and ginger oleoresin and oil, an extraction plant has been established at Laskein Village, Jaintia Hills District, and is ready for production. The mechanical drying and powdering units have also been installed at Laskein village. Mechanical de-starching, drying and powdering of turmeric have successfully been tried. Trial production of oleoresin is being undertaken. A Citrus field germplasm bank (10 ha) has been established at Bibragre

Village, West Garo Hills District and so far thirty two varieties were planted in this germplasm bank.

Plant Biotechnology

The department supported programmes in the area of Plant Biotechnology on basic research, forestry, horticultural and plantation crops, metabolomics etc.

Basic Research

Studies continued on signal transduction pathways in plants to understand the mechanism involved in response to external stimuli and the process of adaptation to these changed environmental conditions.

At University of Hyderabad, role of different signaling molecules was studied on stomatal closure in pea. It was observed that levels of reactive oxygen species (ROS), Nitric Oxide (NO) were found to increase on exposure to abscisic acid (ABA) or Methyl Jasmonate (MJ). The relative kinetics of increase in ROS, NO and cytosolic pH was also observed. There was a strong evidence to indicate that cytosolic pH, ROS and NO interacted with each other.

Molecular basis of potassium nutrition/signaling and functional analysis of calcium

mediated CBL-CIPK (calcineurin B-like and CLB interacting protein kinase) network under potassium deficient conditions was studied in *Arabidopsis*, at UDSC, New Delhi and six interactors of CIPK9 were identified. Further, in order to carry out functional analysis of selected candidate target, homozygous knock out mutants of VDAC3 (voltage dependent anion channel) and AP2C alleles have been developed and over-expression transgenic lines of VDAC3 and AP2C generated.

In order to understand interaction between auxin and sugar signaling pathway, a study was supported at NIPGR, New Delhi. It was observed that glucose not only affects auxin signaling genes but also affects auxin biosynthesis and perception. Besides, glucose signaling affects auxin transporter PIN2 levels, partitioning and auxin polar transport assay. Microarray analysis further revealed that glucose and auxin control a large number of genes both agonistically and antagonistically.

Study was supported to understand membrane biogenesis at IIT, Madras. Subcellular membrane of chloroplast from spinach leaves and vacuoles from beetroot have been isolated and first evidence for presence of biogenic membrane flippase (ATP Independent) and ATP dependent flippase activity have been reported.

Plant growth and development is the result of controlled cell proliferation where MCM (mini-chromosome maintenance) proteins (DNA replicative components) play essential role in DNA replication. The MCM2-7 or MCM4/6/7 complex has been reported to function as DNA helicase in animal and yeast systems. Genes encoding all the six MCMs subunits (MCM2-7) from pea have been cloned and the encoded proteins have been purified. Transcript of MCM6 was up-regulated in salinity and cold stress in pea plant. MCM6 protein was shown to be localized in the nucleus and cytosol. MCM6 single subunit self-interacts and forms a homohexamer which is active for DNA helicase and ATPase activities. MCM6 over expression driven by a constitutive CaMV-35S promoter in tobacco plants confers salinity tolerance.

Solanaceae Genome Initiative

India was a part of International Solanaceae Genome programme and was assigned the responsibility of sequencing 12 Mb euchromatic region of chromosome 5. This task was given to UDSC, New Delhi (5Mb region), IARI, New Delhi (5Mb) and NIPGR (2Mb). The sequencing has been completed and the physical map of the entire genome of tomato is now available. This would help in identification of agronomically

important genes/allele markers linked to important traits under Target Induced Local Lesion in Genomes (TILLING) programme at University of Hyderabad. For TILLING, facility has been established at Hyderabad.

Functional Genomics

Nutritional and shelf life improvement

Metabolic profiling of tomato fruit at various stages of development has helped in identifying genetic loci controlling the characteristics that are related to nutrients and shelf life of fruits. The leads obtained are being taken up further and phase II programme is being initiated to enhance nutrient levels such as flavonoids, carotenoids and folate, using induced mutations/ transgenic manipulations and enrichment of Total Soluble Solids (TSS) in fruits for making tomato suitable for processing. Study is also being initiated on genome analysis of SNP's/mutations/transcript/proteome in cultivars and the wild accessions of tomato using whole genome sequencing and reverse genetic tools for improving desired traits. Transgenic tomato lines expressing polyamine genes under fruit specific promoter for post harvest quality have been developed and are being tested for post harvest quality traits.

Disease Resistance

During Phase-I two transgenic lines resistant to Tomato Leaf Curl Virus (ToLCV) using antisense replicase gene have been developed with dual resistance against virus and insect infestation. Five mapping populations have been generated to identify the source of ToLCV resistance and variety LA1777 has been found to show resistance across India. Besides, SSR, ISSR and SCAR markers have been identified and validated for linkage to ToLCV. Basic information generated during Phase-I is being taken further during Phase-II to develop tomato varieties with broad spectrum resistance to ToLCV and Tospo virus by appropriate gene deployment strategy through marker aided selection.

Network Programme on Metabolomics

A network has been initiated on Metabolomics focusing on crops like tomato, rice, potato, maize, Arnebia, Curcuma etc. Its major focus has been to develop complete metabolomics profile of potato, understand metabolomics of tomato with reference to fruit quality, aroma, nutritional quality, study changes in transcriptome, proteome and metabolite profile in maize (as induced by Nitrogen and Phosphorus stress), secondary metabolite pathway related to shikonin synthesis (Arnebia), metabolomics related to stress and disease

resistance (rice) and assessment of therapeutic properties in curcuma.

At IIHR, Bangalore two lines of tomato 249-15-4 and IIHR-2101 have been found to have higher values for fruit quality parameters. Metabolite profiling of the selected lines has been done for volatile flavour, carotenoids and Vitamin- C parameters while profiling for organic acids, phenolic acids and flavonoids is in progress.

Host Pathogen Interaction

Studies were supported to isolate and characterize secreted salivary gland proteins (SSGPs) from rice gall midge (*Orsalia oryzae*) to understand their role in rice-insect pest interactions at ICGEB, New Delhi. SSGPs have been cloned to generate recombinant SSAPs proteins. Antibodies have been raised against a select sub-set of recombinant SSAPs. Rice hosts when injected with recombinant insect SSAPs showed reactions such as tissue necrosis and typical hypersensitive reaction was observed in resistant hosts. Currently these recombinants are being bulked up for use in plant interaction studies.

At Bidhan Chandra Krishi Vishwavidyalaya Kalayani, a study has been supported to understand the role of biotic/abiotic elicitor induced systemic resistance in rice-

rhizoctonia system. On the basis of virulence, isolates identified have been grouped into five clusters. Three isolates have been confirmed as *Rhizoctonia oryzae* both by morphological studies as well as by ITS (Internal Transcribed Spacer) sequencing. Further studies on biochemical and molecular events during the host pathogen interactions and also biotic and abiotic elicitor based induction resistance in rice *Rhizoctonia* system are going on.

At UDSC, New Delhi and TNAU, Coimbatore studies are underway to understand the interaction between cassava mosaic virus and carrier (whitefly). Protocol has been standardized for inoculation of cloned SLCMU (Sri Lankan Cassava Mosaic Virus) DNA and its whitefly transmission in the laboratory host *Nicotiana tabacum*. Plants have been generated using wild-type viral DNA and the transmission through whiteflies has been achieved. Besides, *in - vitro* interaction studies on viral CP and GroEL proteins of whitefly endosymbionts is in progress.

Madurai Kamraj University has found C2 protein of Bhendi Yellow Vein Mosaic Virus interacting with karyopherin – as well as with itself, suggesting that it may be functioning as a dimer. Further the C2 protein has been shown to transactivate a host promoter. The micro RNA binding

properties of these proteins are being studied.

Viral movement protein encoded by AV2 ORF and the coat protein (CP) encoded by AV1 ORF of a monopartite begomovirus, cotton leaf and kokhran virus-dabawali (CLCuKV- Dab) have been cloned and over-expressed in *E.coli* at IISc, Bangalore. The purified *E.coli* expressed CP has been shown to interact specifically with single stranded DNA via Zinc finger motif with H85 as most crucial residue in the motif. CP was shown to interact with AV2 by ELISA and surface Plasmon resonance. The insect and these markers can be used in plant expressed CP localized in the cell periphery.

At IIHR, Bangalore, four isolates of Cucumber Mosaic Cucumovirus Virus (CMV) have been collected and characterized. Study on mechanism of CMV resistance showed that in VC246 variety no virus replication was observed and cell-cell movement of the virus was also restricted. Inheritance studies using six generation mean analysis of perennial and Pusa Jwala showed single recessive gene for CMV resistance. Further molecular marker linked to CMV resistance in Chilli has been identified and could be used in marker assisted breeding programme.

IHBT, Palampur has identified viruses infecting plum and cherry by ELISA and

dot blot hybridization which was further confirmed by RT-PCR. Complete genome (7379bp) of 3 isolates of Cherry Virus A (CVA) has been cloned and one of them sequenced. It showed 81 and 84% similarity to the type isolate at the nucleotide and amino acid level respectively. This study provides the first report and the complete nucleotide sequence of Cherry Virus A from sweet cherry in India.

Colocasia (taro) and *Amorphophallus* (elephant foot yam) tuber crops and aroid ornamental plants were surveyed in AP and screened for virus infection using DAC-ELISA using heterologous potyvirus antisera. Varying percent infections with plant species and locations was observed. Further, electron microscopy of *Colocasia* dip preparation revealed the presence of flexuous filamentous particle characteristics of polyvirus. Besides, partial genome sequence analysis of potyvirus isolates associated with infection on *Colocasia*, *Caladium* and *Dieffenbachia* species revealed that isolates are phylogenetically closely related to Konjac Mosaic Virus (Ko MV) – Zan reported from Taiwan, and this is the first observation on natural infection of aroids with KoMV in India.

Forestry, Horticulture and Plantation crops

A network project on molecular marker

based breeding in eucalypts was initiated at the Institute of Forest Genetics and Tree Breeding, Coimbatore to develop genetic linkage map and Quantitative Trait Loci (QTLs) identification for two industrially important traits i.e adventitious rooting capacity and wood property traits. Mapping populations for the cross between *E. camaldulensis* X *E. tereticornis*, *E. camaldulensis* X *E. grandis* and *E. tereticornis* X *E. grandis* were generated through controlled hybridization. Field planting of F1 hybrids was completed to clonally propagate the hybrids for multi-environmental phenotyping. The hybridity of the F1s are being confirmed using the simple sequence repeat (SSR) markers. Seventy SSR loci were analyzed for the polymorphism between the parents to generate species-specific linkage map using pseudo-testcross strategy.

An efficient protocol has been developed for multiplication of carnation plants at IIHR, Bangalore. A new variety IIHRP1 was developed and validated in farmers fields and it has been approved for release as 'Arka Flame' by Karnataka State varietal release committee. Another variety IIHRIS-1 has been named as ARKA Tejas and identified for pot cultivation. It is valuable for academic interest and is registered with NBPGR as a valuable genetic stock. Large scale production and demonstration of virus

free tissue culture raised citrus (Nagpur Mandrain) planting material through shoot tip micro grafting has been undertaken.

In order to reduce the cold-induced sweetening in potato, study was supported at CPRI, Shimla. Seven INV RNAi transgenic lines were evaluated along with wild type control Kufri-Chipsona-1 under confined field condition. Yield of two transgenic lines (K.Chiplnv RNAi-2214 and 2123) have been found comparable to non-transgenic wild type control Kufri-Chipsone-1. Transgenic tubers were cold stored at 2°C and its chipping performance was evaluated. Further development of marker-free potato transgenic with improved cold-chipping attributes is being evaluated under glass house conditions.

Studies have been supported on chemotyping and gene expression profiling in black pepper at Kerala Agriculture University, Trissur. Piperine content has been estimated in different stages (native green, native red and dried) of berries in seven black pepper genotypes using HPLC. Dry samples showed more piperine content than fresh samples. Further, during berry development, piperine synthesis was found to begin in the berries 50 days after spike initiation. Cloning of candidate genes related to secondary metabolic pathway is underway.

A study was supported at IIHR, Bangalore to identify markers linked to fruit quality in Guava. Two different mapping populations have been raised and used for genotyping studies. Genotyping has been carried out for parental lines, to screen parental polymorphism by using a set of 237 microsatellite markers. The identified polymorphic markers have been selected for high throughput genotyping of the mapping population.

Apple Network

At NBPGR, New Delhi, study was supported to develop a protocol to cryopreserve apple dormant buds. Natural chilling of budwood was found to be the pre-requisite for post-thaw recovery. Budwood when procured from high altitudes where temperature was upto zero for weeks, responded after cryopreservation. Besides, grafting and patch budding was found to be season based.

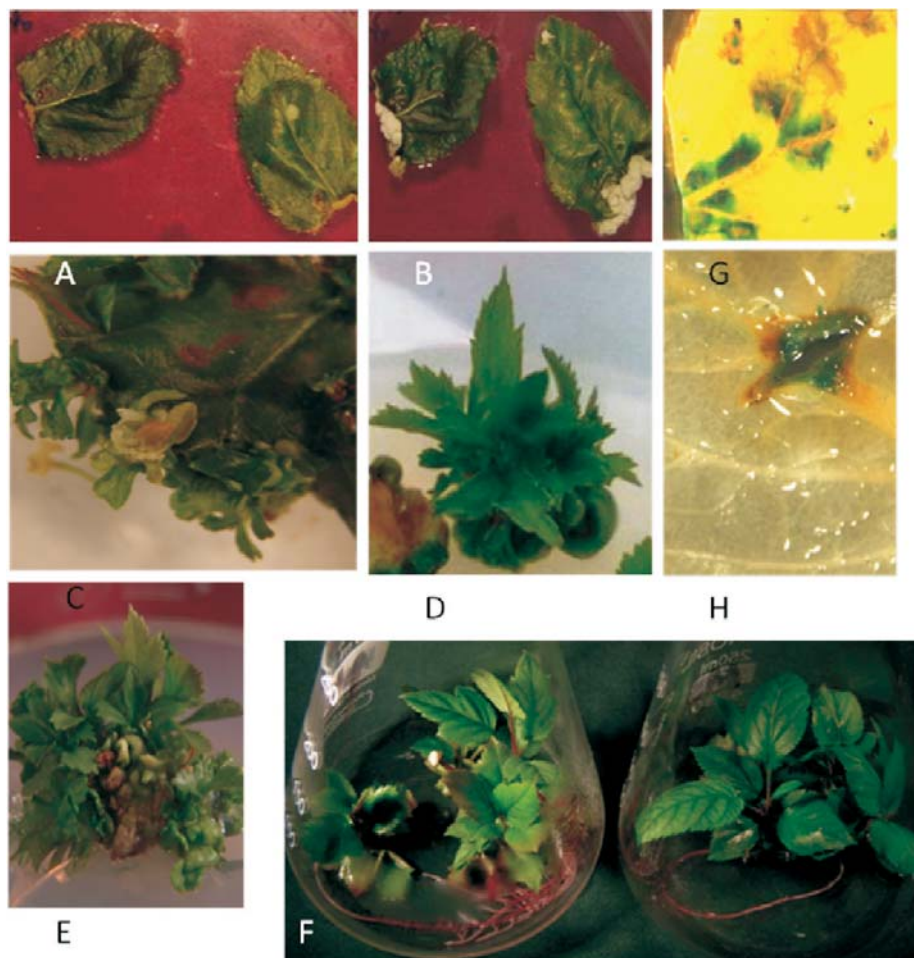


Fig.4.14: Regeneration from leaf explants of apple rootstock, MM106: (A) leaves (B) callusing at excised leaf base (C-E) Indirect shoot regeneration (F) rooting of micro-shoots (G-H) GUS expression on putatively transformed leaf explants



Plants Under Hi-Tech Polyhouse



Hardening of Plants



Hardening of Plants



Rootstocks Planted under Field



Fig. 4.15: Tissue culture raised apple plants being transferred to the field

A network programme on Apple was supported at IHBT Palampur, TERI, New Delhi and CSKHPKV, Palampur under which a tissue culture based protocol for mass production of plants has been developed. The germplasm collected under the network is being screened for virus infestation, nearly 240 samples collected have been screened and 105 samples have been found positive. At

IHBT, Palampur efforts are being made to identify the viral pathogens infecting apple by devising a single assay to simultaneously detect several pathogens at a time. Besides, descriptors are also being developed. An Apple germplasm repository of elite germplasm collected from various regions of the country has been set up at Badarwah Campus, Jammu University, Jammu.

New initiatives

Saffron Network

A Brain Storming Meeting was organized at University of Kashmir, Srinagar to evolve a program on induction of variability for genetic improvement of Saffron, transcriptome analysis to identify genes and regulatory elements that determine floral development and size of corm, development of tissue culture protocol for corm production of desired size, development of agrotechnology for using cormlet of small size and characterization of microflora of rhizosphere associated with Saffron with a target to develop consortia of beneficial microbes.

Metabolomics

A network project on tomato metabolome has been supported at three institutes including Jammu University, UDSC, New Delhi and Hyderabad University. It will cover identification of metabolites from natural accessions followed by mutants and transgenic lines, identify regulatory genes and proteins regulating these metabolic pathways. Subsequently, it would undertake pathway manipulations to increase/decrease the levels of desired metabolites in tomato.

Another network has been supported at JNU, New Delhi and International Institute

of Information Technology, Hyderabad to develop a metabolomic relational database and develop models of metabolite pathway networking and software suitable for predicting networks of metabolite formation, analysis/storage and retrieval of metabolites.

National Certification System Tissue Culture Raised Plants

DBT is successfully implementing the National Certification System for Tissue Culture Raised Plants (NCS TCP) since last five years. The salient achievements of the programme are as follows:

Tissue culture production facilities have been recognized based on infrastructure, technical competency and package practice of production of tissue culture plants. So far 57 companies which have met the necessary criteria have been recognized.

Nine Test Laboratories which are accredited by the NCS-TCP have started functioning for extending services to the tissue culture industry. ATLS are now operational and have tested approximately 7850 samples of various crops from different companies.

Awareness Programme on NCS-TCP

Fifteen programmes were organized

successfully at Lucknow on March 25, 2011 with 136 participants from different segments such as State Horticulture/ Agriculture officials, tissue culture production facilities, representatives of Accredited Test Laboratories, representatives of growers' society, nurseries and progressive farmers. The participants were trained for production of economical crops including banana, sugarcane, potato, vanilla. Initiative has been taken to develop standards for new species potential for propagation through tissue culture. Guidelines for "Testing of mother plants/ stock culture" and "Renewal of Recognition" have been developed and approved. Standard Operating Procedures (SOPs) for ATLS and TCPFs have been revised and relevant formats have been streamlined and adopted. Certification label has been revised and approved for issuance by ATLS to tissue culture production facilities towards certification of tissue culture raised plants. Awareness has been created across the country among all stakeholders through organization of state level awareness programmes.

Medicinal and Aromatic Plants

A programme on biotechnological intervention on medicinal and aromatic plants (MAP) was continued for conservation, isolation and characterization

of novel bioactive agents, development of herbal formulations, genomics and biosynthetic pathway studies. The salient achievements of the programme during the year are as follows:

Ex-situ conservation, reproductive biology and agrotechnology

Important medicinal plants of Manipur hills such as *Paris polyphylla*, *Curcuma angustifolia* and *Zingiber zerumbet* have been collected and maintained in the germplasm bank at Krishi Vigyan Kendra – Sylvan, Senapati District, Manipur. Work on reproductive mechanism of *Picrorhiza kurroa*, *Valeriana wallichii* and *Ferula jaeschkeana* in natural habitats was completed at BGSB University, Rajauri, J&K. Seed germination studies on *Dioscorea vilosa* and *Panax* sp were carried out at Nagaland University, Mokochung. Evaluation of the performance of tissue-culture raised rose scented geranium (*Pelargonium graveoleus*) in Maharashtra state continued jointly in collaboration with Kelkar's Scientific Research Centre, Mumbai and Vidya Pratishthan's School of Biotechnology, Baramati. About 10,000 rooted cuttings of geranium were raised and distributed to the farmers of Baramati district for field trials after a training programme. Demonstration on cultivation and processing of selected aromatic crops

was also undertaken over an area of 50 acres in Dhar block of Punjab state with joint collaboration of Kelkar Scientific Research Centre, Mumbai and Punjab State Council for Science & Technology, Chandigarh.

A network project for identification of high camptothecin yielding clones and development of agrotechnology sustainable harvesting methods in *Nothapodytes nimmoniana* is continuing at UAS, Bangalore, UAS, Dharwad (College of Forestry, Sirsi) and Research and Action in Natural Wealth Administration, Pune. Protocol was standardized for extraction and estimation of camptothecin from leaf tissues of *N. nimmoniana*. Over 5000 seedlings of *N. nimmoniana* were introduced into various agro-forestry systems and coppicing technology to maximize camptothecin yield was developed. Efforts were initiated to develop diagnostics for better management of begamoviruses infecting *Mentha* spp at CIMAP, Lucknow.

Novel bioactive agents and herbal formulation

Double-blind, randomized placebo controlled clinical trials continued on water extract of *Terminalia arjuna* in patients with left ventricular dysfunction at AIIMS, New Delhi. Methanolic extracts of *Cinnamomum*

zeylanicum and *C. cassia* significantly decreased the NO level in murine macrophage cell lines – RAW 264.7 and J774.1 at Interactive Research School for Health Affairs, Pune in collaboration with an industrial partner – M/s Natural Remedies Pvt. Ltd., Bangalore. These extracts resulted into decrease in mRNA expression of proinflammatory cytokines IL1b and TNF α in cell lines. Work on isolation and characterization of anti-cancer compounds from edible mushrooms has been initiated at Indian Institute of Chemical Biology, Kolkata.

Administration of methanolic root extracts of *Coix lachrymosa* at various doses effectively inhibited poisonous snakes (*Naja naja* and *Daboia russelli*) venom induced lethality in mice at NMAM Institute of Technology, Udupi. Myotoxicity induced by both poisonous snakes venom in rats was significantly neutralized by the root extract of *C. lachrymosa*. Ethanolic extract of *Tinospora cordifolia* was found highly active against human epithelial cancer stem cells in a study jointly undertaken at Manipal University, Manipal and Indian Institute of Science, Bangalore. Investigations on extracts of *Withania somnifera* and Withaferin A for their ability to inhibit the phenacetin O-deethylation activity of CYP2A2 using human and rat liver microsomes was initiated at NMIMS, Mumbai.

Studies were initiated on monoherbal preparation and their phytochemical constituents against Hepatitis-B virus jointly at Institute of Liver and Biliary Sciences, New Delhi and CIMAP, Lucknow. Significant anti-Hepatitis-B activity was recorded in the extracts of *Phyllanthus amarus* and *Silybum marianum* in *in vitro* tests using Hep G 2.2.15 and Hep G2 cell lines.

Genomics and biosynthetic pathways

Eleven genes involved in mucilage biosynthetic pathway were identified in Isabgol (*Plantago ovata*) at University of Jammu, Jammu. Efforts were made for isolating the key regulatory genes responsible for santalol production in sandalwood (*Santalum album*) at Vittal Mallya Scientific Research Foundation, Bangalore. Studies on designing and preparation of microarray chip to analyze the terpene pathway in aromatic plants is progressing at CIMAP, Lucknow.

Animal Biotechnology-Production

Efforts continued to enhance the productivity of livestock. During the period, two brain storming workshops were organized in the areas of poultry biotechnology and lignocelluloses degradation and priority areas were identified for generating new programme.

Salient achievements in the R&D programmes were:

Transgenics

At CCMB, Hyderabad, a knockout mice model was developed by deleting Wdr 13 gene in mouse embryonic stem cells through homologous recombination to analyze its role in obesity and metabolism. The interacting portions of the Wdr 13 protein viz. PHIP, ER α , ER β , HDAC1, HDAC2 and HDAC7 which play important role in the regulation of a wide variety of cellular functions were identified. These mutants were bred in the background of db/db knockout animals which will help in understanding the structure of Wdr13 and db locus.

Attempts are being made to express human proteins of therapeutic value in the milk of buffalo at NII, New Delhi. A full length promoter of buffalo beta casein gene was isolated, cloned, sequenced and characterized in terms of its activity. The green fluorescent protein (GFP) was cloned under this promoter and MCF 7 cells (human breast cell line) were transfected *in vitro*. The construct was used to generate transgenic mice for checking *in vivo* activity of buffalo beta casein promoter. The breast gland of lactating females of F1 progeny of mice confirmed its activity.

Animal Reproduction and Related Areas

The role of imprinting cluster on rat chromosome during embryogenesis was studied at NIRRH, Mumbai. The study confirmed that the imprinted genes regulate embryo growth whereas aberrant expression of imprinted genes was associated with embryo growth disorders. The study confirmed that paternal administration of tamoxifen led to aberrant expression of imprinted genes in the F1 embryos which presumably abrogate Notch and Wnt signaling leading to cell cycle arrest, affecting embryo-placental growth and development and ultimately causing embryo loss.

Efforts were taken to enhance the productivity of Mithun at NRC on Mithun, Medziphema, Nagaland. The artificial insemination technique and preservation of Mithun semen were successfully standardized and calves were produced using cryopreserved semen both at farm and field levels. The protocols for superovulation and ETT were also standardized. Mithun cows were superovulated using FSH and recovered embryos were transferred in to the recipient animals. Out of six embryos transferred to the recipient, two animals maintained pregnancy. It was found that hCG @ 1500 IU and 3000 IU was optimum for induction

of ovulation of Mithun cows with spontaneous and superovulatory estrus respectively.

Efforts are also on to conserve quality Yak germplasm and its multiplication at NRC on Yak at Dirang, Arunchal Pradesh. Yak embryos were developed *in vitro* up to blastocyst stage where as Yak hybrid embryos could be developed upto morula stage. A few of the embryos developed were transferred to the recipients and pregnancies were confirmed. Some of the embryos were cryopreserved using vitrification method. The ovum pick up (OPU) technique for harvesting embryos from live Yaks was also standardized in collaboration with NDRI, Karnal.

Sperm specific antigens with immuno-contraceptive potential were identified, isolated and characterized in dogs at GADVASU, Ludhiana. Dogs and bitches were immunized against purified PH-20 and LDHC sub units of antigen to observe their effect on sperm parameters and fertility. Immunofluoresence of anti-PH and LDHC sub units with dog spermatozoa indicated scattered localization of PH-20 sub units on the entire head surface and that of LDHC sub units mainly on the acrosome. The study confirms that LDHC and PH-20 antigens have immunocontraceptive potential.

The effect of zinc (Zn) supplementation on growth, immune response and reproduction of female rats were conducted at SVVU, Hyderabad. The study indicated that 12 ppm Zn supplementation in feed was optimum for growth, while 36 ppm was required for obtaining higher immunocompetence in rat model. The serum progesterone concentration was found to be higher in rats with Zn supplemented feed compared to standard feed and the ovarian histology indicated lower percentage of atretic follicles along with higher antral follicles and well developed corpus lutea with 24 and 36ppm of Zn supplementation respectively. The Zn deficiency was found to depress body weight gain, feed intake, immune response and reproductive efficiency.

Expression and localization of autocrine and paracrine factors and their receptors regulating corpus luteum (CL) function during the estrous cycle of buffaloes was studied at IVRI, Izatnagar. All the vascular endothelial growth factor (VEGF) isoforms were found in the buffalo CL during the estrous cycle. Analysis of the VEGF transcripts showed that CL predominantly expressed the two smallest VEGF isoforms i.e. VEGF₁₂₀ & VEGF₁₆₄ and weakly expressed the VEGF₁₈₈ isoform. The highest VEGF mRNA expression was detected during the early luteal phase of the estrous

cycle followed by a significant decrease of expression during the mid and late luteal phase and a further decrease of VEGF mRNA after regression. These results suggest an important role of VEGF in angiogenesis of the newly formed CL in buffalo.

Estrus-specific pheromones were assessed for their possible role in early pregnancy detection in buffalo at Bharathidasan University, Truchirappalli. Various estrus specific compounds were evaluated and 4-methyl phenol was found promising for estrus detection. The estrus stage urine sample gave considerable elevated colour change with 4- methyl phenol compared to other stage of urine samples. The estrus specific urine also showed significant result in the absorption spectra at 558 nm. Efforts are on to develop an estrus detection kit using urine samples.

Genetic Characterization and Genome

The satellite tagged genes of water buffalo, *Bubalus bubalis* were characterized at NII, New Delhi. Four *RsaI* repeat fragments viz. pDp1, pDp2, pDp3 and pDp4 of 1331, 65, 603 and 339 base pairs, respectively of buffalo were cloned and sequenced. These fragments were found to represent retro-transposons and part of some functional genes. *RsaI* repeats were found to be

transcriptionally active in somatic tissues and spermatozoa. The pDp1 showed maximum activity in lung; pDp2 and pDp3 in kidney and pDp4 in ovary. The study suggests that *RsaI* repeats have been incorporated into the exonic regions of various transcribing genes, possibly contributing towards the architecture and evolution of the buffalo and related genomes.

The genetic diversity and population structure of different Indian zebu cattle breeds were studied at NBAGR, Karnal. All the breeds analyzed other than Nagori and Kangayam had substantial within breed genetic diversity with moderate levels of breed differentiation. The genetic distances showed close grouping of Mewati and Kankrej cattle whereas Kangayam and Nimari cattle exhibited highest genetic difference. Majority of the breeds from North and North-Western region grouped separately from that of breeds from Southern region. The mitochondrial D-loop based analysis on 20 cattle breeds revealed that Southern, draft purpose and grey coat color breeds are more diverse. The phylogeography and network analysis revealed Southern breeds to be primitive in comparison to Northern cattle breeds. The candidate gene analysis across the breeding bulls utilized in artificial insemination revealed that except at Beta-casein locus (A2

allele), the frequency of functionally important alleles is low at other analyzed loci, suggesting the need for screening of the breeding bulls before selection.

The fecundity of local sheep breed of Kashmir is being enhanced by introgressing fecundity B (*FecB*) gene at SKUAST, Srinagar. During the course of the study, the reproductive performance of the animals with introgressed *Fec B* gene was reported to be a litter size of 146% against 86-92% in the sheep without *Fec B* gene. The study also confirmed that the *Fec X* mutation conferring high litter size in the Kashmir sheep was not segregating and the existence of *Fec B* gene in such animals ruled out. A new mutation in exon 2 of *Fec X* gene between 1022-1243 bp area was also observed. The study helped in enhancing the productivity of local sheep breed. In another study, the productivity and reproductive efficiency of Lonand strain of Deccani sheep was also enhanced at farmer's level by introgressing the mutation of *Fec B* by crossbreeding at NARI, Phaltan. The litter size of *Fec B* carrier sheep was increased and to enhance the chances of their survival, a small quantity (~200 gm per day) of supplementary feed to the ewes just before lambing to about two months after lambing was found to be cost effective and could yield double the profit per ewe as compared to non-carrier ewes.

Animal Nutrition

Tannin degrading bacterial isolates were isolated and evaluated as a probiotic to improve utilization of tree leaves containing high tannin at IVRI, Izatnagar. A total of 69 tannin degrading bacterial species were isolated from the rumen of goats fed on oak leaves / pakar leaves as major roughage source. Out of 69 tannin rumen bacteria isolated, 22 isolates showed improvement in IVTD of oak leaves. The isolates exhibited good tannase activity and tannin degrading ability. On the basis of biochemical characterization, bacterial isolate TDGB 406 was used as a probiotic for the feeding trials in goats and improved growth performance and FCR was found in goats fed on oak leaves as one of the main roughage source.

Efforts are underway to utilize Sheanut cake as an energy supplement in livestock feed to replace high cost low energy supplements like deoiled rice bran at SVVU, Hyderabad. Chemical analysis of Sheanut cake confirmed high amount of crude protein, crude fibre, minerals and essential amino acids. The experiments in sheep and buffalo calves were carried out to study the growth, nutrient digestibility and economics of meat production. The dry matter intake and average daily weight gain was significantly higher in the animals fed with Sheanut cake rations compared to

control diet. The dressing percentage and edible organs percent was also increased as the Sheanut cake percent increased in the ration along with inclusion of probiotics. The study revealed that the Sheanut cake can be safely utilised as a feed ingredient up to 40% level with or without probiotics in sheep and buffalo calves to reduce the cost of production of meat and for effective utilisation of unconventional feed stuffs.

Utilization of agro-forest based non-conventional oil cakes as an alternate to oil cakes as a protein source in feed was taken up. The feeding trials of detoxified jatropha, karnaj and neem oil cakes were conducted in small ruminants to validate their potential use as protein supplements. It was found that detoxified jatropha and neem cakes can be used as a replacement of soya bean meal to up to 75% level in the diet of sheep and goats without any adverse effects on nutrient utilization, nitrogen metabolism, immune response and meat quality. Detoxified karanj, on the other hand, can be used at a maximum of 50% level of replacement of conventional protein meal. Encapsulation process for feed enzymes was developed at SVVU, Hyderabad to improve their heat tolerance and storage stability. Studies on storage and thermal stability of commercial enzymes viz. amylase and xylanase indicated that the activity of these enzymes declined slowly in the encapsulated

form where as in the non-encapsulated forms the activity declined rapidly even during storage at room temperatures. The sugar release activity in feed of amylase and xylanase was not influenced by encapsulation of enzyme at pelletization temperature of 70°C for four minutes. However, there was a significant retention of amylase and xylanase activity in encapsulated enzyme at both 80°C and 90°C of pelletization for four minutes. The results indicate that the encapsulation of amylase and xylanase enzymes with sodium alginate offers protection against thermal inactivation.

Studies on the effect of micronutrients supplementation on immunity and productivity of indigenous cattle were conducted at NDRI, Karnal. The micronutrients supplementation significantly reduced oxidative and metabolic stress during calving period. Leptin levels were found to decrease before calving and remained low after calving period. Insulin concentrations differed according to days postpartum: levels started to decrease before parturition, minimum concentrations were found around parturition but levels were fully recovered after 30 days postpartum. Plasma concentrations of GH increased at parturition and remained elevated after calving. There was a significant increase in the levels of leptin, insulin and growth hormone in cows supplemented with

micronutrients. Immunity of cattle was found to be enhanced significantly with the supplementation of micronutrients. The milk yield was also enhanced with the group of cattle with micronutrient feed.

Poultry

Molecular evaluation of forced moulting in white leghorn hens and its possible effective alternatives were studied at CARI, Izatnagar. The differential expression patterns of candidate genes (apoptotic and cytokine) responsible for regression/rejuvenation of reproductive tissues of white leghorn hens during forced moulting were studied and few critical genes (Caspase 1, Caspase 2, Caspase 6, BOK, Bcl 2, p53, IL1, IL6, IL10, TRAIL, T and TG) responsible for regression/rejuvenation were identified. A new method of forced moulting using Zinc and Chromium was developed which can be effectively used at the commercial scale and also complies with the animal welfare norms.

QTL markers for growth traits were identified in broiler chicken at PDP, Hyderabad. Three strains of chicken viz. PB-1, CB and IWI were generated to explore polymorphism of myostatin promoter. A total of 4 haplotypes were found across the populations. The haplotype, h1 was the most predominant allele in all the populations, while the least frequent haplotype varied from strain to

strain. The haplotype combinations showed significant effect on body weights at 6 weeks in PB-1 and IWI lines and 7 weeks at CB line. In PB-1 line, h4 showed the highest growth rate both between 4-6 and 6-7 weeks. In CB line, h3 group had the highest growth rate between 6-7 weeks. The relative expression profile of myostatin gene in different haplogroups revealed that h1h2 haplogroup had the highest expression as compared to other haplogroups suggesting a significant role of the gene in regulating growth in chicken.

Efforts were made to enhance the productivity of Emu at MVC, Chennai. Male Emu birds were trained for semen ejaculation using an artificial cloaca fabricated by the investigators. So far, three male Emus were trained efficiently for ejaculation procedures. The average daily output of semen from the trained emus was observed at the rate of 0.3 ml to 0.7 ml. The initial motility of the spermatozoa ranged between zero to 40 per cent. Sex determination technique for Emu is being standardized.

Animal Health

The department has been implementing programs in animal vaccines and diagnostics and collaborative and coordinated research for the translation of existing candidate vaccine technologies and diagnostics for field use through product development to commercialization.

A “Translational Research Platform for Veterinary Biologicals” (TRPVB) has been established at Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), Chennai in September 2011 in partnership with DBT. This platform would facilitate the translation of technologies by performing product development, validation, obtaining regulatory approvals to facilitate product commercialization and also be a referral center to strengthen linkages and collaboration in the area of animal vaccine and diagnostics development, exchange of biological materials, technology assessment, supporting training, consultation and intellectual property development.

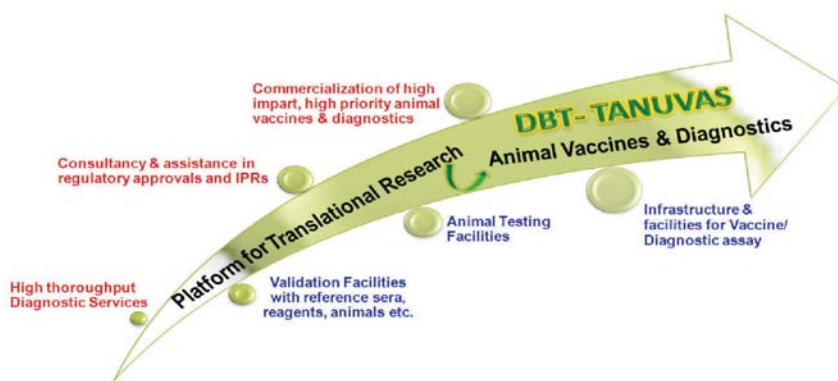


Fig. 4.16 : Diagrammatic representation of services offered by TRPVB

International experts were involved in reviewing the progress of Network Project on Classical Swine Fever for smooth running of the program and to overcome the shortcomings of the results of swine fever network project under CSF Network programme one National and five Regional referral CSF laboratories have been established in different regions of the country. Rapid and precise diagnostic tools for CSF: (TaqMan)-reverse transcriptase (RT) PCR assay was developed for detection of CSFV in tissue samples originating from pigs suspected for CSF. Isolation and adaptation of CSFV in PK-15 cells along with production and characterization of monoclonal antibodies against CSFV was carried out.

A mini workshop on “Health Monitoring of Laboratory Animals” involving potential users and selected stakeholders was organized at IISc, Bangalore was organised for discussion on important diseases of small laboratory animals relevant to Indian subcontinent that need to be screened periodically, various parameters which needs to be considered while monitoring the health of experimental animals like number of animals screened, collection of right specimen, usage of appropriate method, etc. The workshop of DBT Network Project on Brucellosis was held in August, 2011 at NII, New Delhi in which the issues

and challenges for development of Brucellosis Network Project were discussed. With the recommendation of international and national experts a Network Project on Brucellosis was formulated and recommendations were made to set up six Epidemiology units, two Repositories, two projects for development of animal and human vaccines respectively, three projects for development of diagnostic kit for animal and one project on bioinformatics related work. Five papers have been published in national and international journals through the projects funded.

Vaccines and Diagnostics projects implemented are summarized as under:

Seroprevalance and molecular biological approach for diagnostics of canine monocytic ehrlichiosis in various regions of India

A total of 350 canine samples were processed using nested PCR targeting 16s rRNA gene for detection of *E. canis*, of which a total of 19 samples have been detected positive for *E. canis* and one sample for *Anaplasma platys* as also confirmed by sequencing their PCR amplified products. PCR for detection of Babesia which is also a tick borne disease has been standardized and out of a total of 409 samples screened by this PCR, 76 have been found positive,

as also confirmed by sequencing their PCR amplified products. Indirect Fluorescent Antibody Test for estimation of antibodies against *E. canis* from canine serum samples has also been standardized and data on clinico-pathological changes in *E. canis* infection is being recorded.

Development of vaccine for control of bovine tuberculosis

The animals were clinically examined; blood samples were collected for routine haematological assessment, baseline detection of intracellular cytokines in T cell subsets (CD4 & CD8) and screening for mycobacterial pathogens by molecular beacons and culture was done. The animals were immunized with live BCG and heat killed *Mycobacterium W*, recombinant BCG over expressing SOD and 85C antigens. For DNA vaccines the intra-muscular (rump) and rBCG vaccines the intra-dermal (neck left and right) route of immunization were used. After immunization blood samples were collected at various time intervals. The PBMC have been isolated from the animals at each time point and cryo-preserved. These samples were revived for *in vitro* assessment of immune response to mycobacterial antigens during the extension period by real time PCR for cytokines and other related immunological parameters.

Development of recombinant fusion protein vaccine for *Mycobacterium avium sub sp. Paratuberculosis*

The fusion clones of 85A and 85B gene of bacteria were generated and expression was confirmed. Chitosan nano particles were produced and assessed for their characters. Preliminary studies with heat killed chitosan coupled MAP vaccine and 85A+85B fusion antigen were found to be safe and resulted in Th1 and Th2 response.

Identification of target molecule on B cells which binds Infectious Bursal Disease (IBD) virus and its regulation for immunoprophylaxis of IBD in chicken

The investigation could lead to valuable new insights into the identification of the target which can be an effective therapeutic and be used for prophylactic measures for the control of this important infectious disease which causes huge economic losses to the poultry industry worldwide. Experimental studies carried out have yielded new results which indicate that MHC class II molecule present in large quantities on immature B cells in the bursa of young chicks is the putative target for the IBD virus. The binding of IBD virus to chicken MHC II molecules on developing B cells in the bursa prevents their interactions with the non-lymphoid bursal cells which

is essential for their survival and maturation. Thus, blocking of MHC II on immature B cells by IBD virus in chicken Bursa may lead to apoptosis in B cells causing large scale destruction of B cells and hence immunodeficiency in young chicks.

Aquaculture and Marine Biotechnology

In Aquaculture & Marine Biotechnology programme, projects were supported on aquaculture feed, development of therapeutic feed, identification of novel bioactive molecules, marine extremophiles, molecular characterization, induced maturation in shrimp, production of male ornamental fish, and development of molecular markers for disease resistance, diagnostics and vaccines, *in vitro* model for viral replication, development of cell lines etc. An Indo-Norway joint collaborative programme on fish vaccine development was implemented. Technologies were developed and patented with the leads obtained, along with a good number of publications in this programme. Some of the important achievements of the programme are as follows:

Aquaculture Feed

Development of enriched aqua-feed with

cellulolytic and amylolytic microbes was carried out at Kakdwip Research Centre of CIBA. This study was undertaken to identify the potential of isolated cellulolytic and amylolytic microbes from the gut of brackishwater fishes by supplementing them in the diet of Seabass (*Lates calcarifer*) and *Mugil cephalus* (Grey mullet) in feed utilization efficiency and digestibility. The *in vivo* trial on *M. cephalus* juveniles revealed that fermented ingredients could replace 75% of fish meal in diet of *Mugil cephalus* juveniles without affecting growth rate, FCR, PER and survival. Supplementation of live bacterial mixture (*Bacillus subtilis* DDKRC5 and *Bacillus sp.* DDKRC1) or feeding of microbial fermented ingredients could reduce *Vibrio* load in water though total microbial load in water did not differ significantly when compared with tank water of control. Feed supplemented with a mixture of *Bacillus subtilis* DDKRC5(CCx) & *Bacillus sp.* DDKRC1 (LC8) showed higher weight gain ($141.42 \pm 2.76\%$), lower FCR (2.15 ± 0.03), higher nutrient digestibility, better gut microbial and digestive enzyme status in Asian seabass juveniles.

The studies on immunostimulatory property of seeds of *Achyranthes aspera* (Amaranthaceae) in Indian major carp *Catla catla* was carried out at Delhi University. The larvae of *C. catla* were fed with diets containing raw seeds and crude extract of

seeds with control diet. Fish were challenged with *Aeromonas hydrophila* after one month of feeding. Group of fish exposed to UV-B radiation (80 μ W/ cm²) for 10 min for 40 days were fed with seeds of *Achyranthes aspera*. Incorporation of seeds of *Achyranthes aspera* in diet of fish showed promising results to overcome the problem of UV-B radiation in aquatic system. Feeding of carp larvae with seed at 0.5% level improved the non-specific immunity at early developmental stage and it enhanced the resistance of fish against the pathogen. Dietary supplementation of seeds resulted in enhanced growth rate of fish. Best performance was found in raw seeds incorporated diet fed carp, but the diet containing either extract of the seeds showed promising results.

Shrimp Therapeutic Feed

An Integrated Disease Management (IDM) System for Sustainable Shrimp Farming was developed at Bharathidasan University, Tiruchy. A therapeutic feed was formulated from marine red alga, *Asparagopsis taxiformis* for the management of Vibriosis in *Penaeus monodon*. The product developed is suitable to be used as an alternative to antibiotics. The efficacy was proved in statistically designed experimental trials conducted through *in vitro*, *in vivo*, *in captivity* and field trials. The consequence of the antibiotics in

shrimp aquaculture can fully be prevented, as the newly developed product, *Asparagopsis* diet is a natural algal-based product, which will not have environmental consequences as recorded in the use of antibiotics. It was found that haemogram profile of the medicated shrimp enhanced considerably when compared to the control groups. Similarly, the agglutination titer, serum bactericidal activity and phagocytic rates of the medicated shrimps were higher. The PO activity of the 1.2 g/kg treated shrimp group (10.7 ± 2.8) was higher than that of control (4.8 ± 3.2). Based on the results it can be concluded that *Asparagopsis* incorporated feed at a dose level of 1.2 g/kg significantly improves survival, growth and yield under real farm conditions.

Induced maturation in shrimp

Molecular signalling for induced ovarian maturation of *P. monodon* was studied at University of Madras, to overcome the problems of excessive loss of hemolymph and susceptibility to infections faced in traditional eyestalk ablation process. Molecular signal interventional approach using MEK inhibitor has been used as an alternative technique. The expression of phospho ERK was predominantly detected in the eyestalk XO-SG complex of control animal. Gonadosomatic index (GSI) was assessed for the ovarian maturation. The

shrimp treated with inhibitor attained fully mature stage and spawned at ~96 hrs, where as unilateral eyestalk ablated shrimp spawned at ~144 hrs. Statistical analysis showed a highly significant increase ($P < 0.05$) in the mean of GSI of shrimp treated with inhibitor over ablated and control shrimp. The shrimp showed excellent response to this inhibitor treatment than eyestalk ablation. The study could lead to alternative method to induce maturation in shrimp.

Disease Resistance Molecular Markers

A project on identification of disease resistant giant Black Tiger Shrimp, *Penaeus monodon* using molecular markers was implemented by Bose Institute, Kolkata. With this aim, highly statistically significant DNA marker of 455 bp by RAPD method was identified to screen the disease-resistant shrimp populations and disease susceptible populations. An attempt was made to screen disease resistant *P. monodon* among wild populations at four different geographic locations in the East cost of India as well as 35 different cultured ponds using DNA marker. Challenge experiment was also carried out in screened shrimp with WSSV. The sequences were subjected to NCBI mega blast to find homology with other sequences and showed similarity with mainly two types of proteins such as membrane bound protein and proteins

related to metabolic pathway of various organisms. This strategy would be useful to identify the disease resistance gene and also to understand molecular mechanism of white spot disease in *P. monodon*.

In another project, improvement of disease resistance in rohu carp and tiger shrimp was undertaken by developing marker resource, real time expression analysis, survival data analysis and immune parameter studies including screening of microsatellite markers. The results suggest that innate immunity is enhanced in native resistant line fish because higher quantities of particular compounds are expressed, and because of the presence of particular polymorphisms, or linked genes. This has demonstrated the utility of identifying genes associated with disease resistance. A number of the putative rohu SNPs were tested and these are ready for use to perform a thorough scan for genes associated with disease resistance.

In vitro model for WSSV replication

A project was undertaken to develop an *in vitro* system from *Penaeus indicus* and freshwater crab *Paratelphusa hydrodomous* for WSSV replication, pathogenesis and quantification at C. Abdul Hakeem College, TN. An attempt was made to develop an *in vitro* system from marine shrimp (*Penaeus*

indicus) and freshwater crab (*Paratelphusa hydromous*). The results of PCR and Western blot revealed the presence of WSSV in hemolymph, eye muscle, gill and heart tissue of freshwater crab and these organs were found to be highly susceptible to WSSV and more suitable for WSSV propagation. The transcriptional and translational analyses of VP28 gene of WSSV in different organs of WSSV-infected crab revealed the multiplication of WSSV in heart tissue, gill tissue, hemolymph and muscle. *In vitro* system was successfully developed using heart explants of freshwater crab. The heart explants were maintained in viable condition using modified EX-CELL 405 cell culture medium without serum for more than 50 days. The results of PCR, RT-PCR, Western blot, histology, and immunohistochemistry revealed the replication of WSSV in heart explants of crab. The overall results revealed that the heart explants of freshwater crab was found to be a promising *in vitro* system for WSSV replication and also for screening antiviral substances against WSSV.

Development of RT-PCR kit for the detection of fish nodavirus

A collaborative project on characterization and development of diagnostics for viral nervous necrosis in sea bass (*Lates calarifer*) and mullet (*Mugil cephalus*) was implemented by CIBA, Chennai and C.

Abdul Hakeem College, TN. A RT-PCR based assay and a prototype kit for the detection of betanodavirus causing Viral Nervous Necrosis (VNN) in fish was developed and standardized. The assay and kit have been validated extensively using field samples of clinically and sub-clinically infected fish (freshwater, brackishwater and marine) from different parts of the country. The kit can be used for the routine diagnosis of disease, besides as a management tool to screen broodstock, larvae and even trash fish used as feed in fish hatcheries and also in developing specific pathogen-free stock development.



Fig.4.17: Betanodavirus assay prototype kit

Marine Carotenoids

Isolation of carotene-protein from shrimp waste by autolysis technique was carried out by

CFTRI, Mysore. Autolysis conditions were standardized to prepare carotene-protein isolate rich in antioxidant activity. Antioxidant activity of crude carotenoid extract from shrimp waste and its fractions was evaluated by *in-vitro* and *in-vivo* techniques. Different *in-vitro* antioxidant assays indicated the strong scavenging activity of shrimp waste extract and the astaxanthin fraction separated from crude carotenoid extract. The extracts were also able to inhibit the oxidation of lipids in liposome membrane model system. The antioxidant activity of the extracts was demonstrated through *in-vivo* studies using rat feeding experiments. Carotenogenic bacteria were isolated from marine environment and their ability to produce carotenoids was evaluated. The conditions for extraction of carotenoids from *Flavobacterium* sp. were also standardized. The hydrolyzed protein isolate showed higher antioxidant activity compared to that obtained by the pH shift method. The proteins are broken down to smaller units and the low molecular peptides result in higher antioxidant activity of the hydrolyzed proteins. The protein isolates also contain a considerable amount of carotenoids. Thus the protein and carotenoid rich protein isolate obtained from shrimp waste would find use in aquaculture nutrition.

Genomic Characterization

Genome characterization and mRNA

transcript analysis of novel gene Serine Proteinase and alpha-2- macroglobulin from shrimp *Fenneropenaeus indicus* was carried out by Alagappa University. Alpha-2 macroglobulin (A2M), a non-specific protease inhibitor involved in host defense, is a glycoprotein found in almost all taxonomic categories of animals. As proteinase inhibitor, it regulates protein degradation activity in tissues. The expression of serine proteinase were analysed in different tissue of *F. indicus* and the mRNA transcripts were analysed after the injection of bacterial challenge with *Vibrio* (*V. harveyi* & *V. parahaemolyticus*). The tissue expression profiles and challenge-induced expression of these genes were assayed. Three A2Ms isoforms were identified in *F. chinensis* and it has been found that the sequence of *F. indicus* A2M have high similarities (82%) with FcA2M-1. This suggests that the different types of A2M carry out different functions and are not simply functionally redundant. Functional studies on shrimp A2Ms in *F. indicus* would help to elucidate A2M defence mechanisms and also clarify the evolutionary relationship between A2M-FI and its molecules.

Bio-active Compounds

A collaborative project on characterisation of bioactive compounds from marine Mollusc and Porifera that regulate

osteoclastogenesis was implemented by ACTREC, Navi Mumbai and the D. G. Ruparel College of Arts, Science and Commerce, (DGRC), Mumbai for exploiting the source of potent bioactive compounds as marine natural products. Incremental changes in the rate of bone resorption can lead to bone disruption and cause major bone diseases, including osteoporosis, bone metastasis, and rheumatoid arthritis. The marine extracts of mollusc *Turbo brunneus* and porifera *Tethya spp.* showed a good antiosteoporotic activity in ovariectomised mice model. Inhibition of osteoclastogenesis was shown by TME and its fractions. Raman spectroscopy studies showed increased mineralisation in the bones of mice treated with TME and SPPE. Ovariectomised mice were used as estrogen deficient model for studying antiosteoporotic effect of marine extracts Turbo Methanol Extract (TME) and Petroleum Ether soluble portion of methanol extract (SPPE). Oral administration of TME and SPPE to ovariectomised mice could reduce the increased bone resorption and trabecular thinning and leading to bio-prospecting of novel bio-active compounds from marine species.

Cell line development

Establishment and characterisation of cell lines from selected marine food fish and ornamental fish was continued at CMFRI,

Kochi. Eighteen cell lines have been developed from 4 species of commercially important marine fishes i.e. Cobia (*Rachycentron canadum*), honeycomb grouper (*Epinephelus merra*), rabbit fish (*Siganus canaliculatus*), and the marine ornamental fish *Dascyllus trimaculatus*. Three cell lines were developed from the fin and caudal peduncle of the three spot damsel, *Dascyllus trimaculatus*. Six successful cell lines have been developed from various tissues of the cobia, *Rachycentron canadum*. Cell culture systems have been developed from the honeycomb grouper, *Epinephelus merra*. These cell lines were cryopreserved in liquid nitrogen and their subsequent revival showed >80% survival rate. The cell lines are being characterised by chromosome analysis, immunophenotyping, transmission electron microscopy and molecular techniques.

Development and characterization of cell lines from *Etroplus* for virological and toxicological applications was implemented at C. Abdul Hakeem College, TN. Cell lines from tissues of eye, gill, kidney and brain of *Etroplus suratensis* were developed and characterized. These cell lines showed predominantly epithelial-like cells. Effects of temperature and foetal bovine serum concentration on the growth of these cell lines were examined and optimum growth was found at the temperature of 28°C with

20% foetal bovine serum. All the four cell lines were successfully cryopreserved and revived at different passage levels. The cells of these cell lines were successfully transfected with pEGFP vector DNA. The eye (IEE), gill (IEG) and kidney (IEK) cell lines were found to be susceptible to nodavirus but resistant to infectious pancreatic necrosis virus (IPNV).

At CUSAT, Kochi a growth medium exclusively for shrimp lymphoid cell culture was developed as a major block in the establishment of cell lines from shrimp due to lack of a specific cell culture medium for the cultivation of shrimp cells *in vitro*. A novel cell culture medium named SCCM (Shrimp Cell Culture Medium) has been developed and validated exclusively for shrimp cell culture *in-vitro* and monolayer of lymphoid cells developed in SCCM medium. This has helped in identification and removal of blocks on *in-vitro* transformation and establishment of permanent cell lines from *Penaeus monodon*. A patent application has been filed through DBT.

Marine Extremophiles

Studies on isolation, cloning and production of industrially important cold adaptive enzymes from marine extremophiles were carried out at Acharya Nagarjuna University,

Andhra Pradesh. The isolated β -galactosidase producing deep marine bacterium from Bay-of-Bengal was investigated by 16S rRNA, FAME, biochemical and TEM analysis and was identified as gram negative, spiral shaped, motile belonging to the class *Alphaproteobacteria* and the genus *Thalassospira*. The optimum growth temperature and tolerance against the salt concentration suggested that the isolated bacterium was categorized as haloplanktic psychrophile. Moreover it has shown 10% to 30% of β -galactosidase activity at 5°C to 15°C, whereas the thermal stability of the enzyme was 0°C to 30°C at pH 6.5. A comparative docking study of psychrophilic β -galactosidase with lactose, ONPG, and PNPG against the β -galactosidase from mesophilic and thermophilic sources revealed that psychrophilic β -galactosidase showed more binding affinity towards the three substrates when compared with other two sources. The enzyme has shown high specific activity at low temperatures when compared with mesophilic and thermophilic enzymes.

Indo-Norway Collaboration on Fish Vaccine

A multicentric Indo-Norwegian programme on vaccine platform was continued. Work on development and evaluation of bacterial (*Aeromonas hydrophila* and *Edwardsiella tarda*) vaccines for finfish based on outer

membrane proteins (OMP) was initiated at College of Fisheries Mangalore. *Aeromonas hydrophila* is responsible for serious economic losses for fish-farming industry due to serious disease manifestation in a number of ways such as fin rot, tail rot, hemorrhagic septicemia, dropsy, ulceration, asymptomatic septicemia, exophthalmos etc. A recombinant vaccine was developed against this pathogen. Fish immunized with this recombinant protein was found to be highly protected (RPS ~ 65%) when challenged with *A. hydrophila*. The vaccine was highly immunogenic as seen from the high antibody titre recorded in immunized fish, level of which was maintained for over two months. *Edwardsiella tarda* is also a major concern to the aquaculture industry. A recombinant vaccine was also developed against this pathogen. Fish immunized with this recombinant protein were seen to be highly protected (RPS ~70%) when challenged with *E. tarda*. The vaccine was highly immunogenic as seen from the high antibody titre recorded in immunized fish, the level of which was maintained for over two months. The study indicates the potential of the OMPs for protecting carp and rohu through vaccination.

In another programme, work on Immunomodulation studies in freshwater prawn *Macrobrachium rosenbergii* using recombinant proteins of *Macrobrachium*

rosenbergii nodavirus was carried out with the collaborative efforts of CIFA and CIBA. Based on the sequence analysis of three MrNV genes (Capsid, RdRp, B2), the tertiary structure was predicted using I-TASSER software. In the absence of any therapeutics to control white tail disease (WTD) in *Macrobrachium rosenbergii*, recombinant proteins of *M. rosenbergii* nodavirus (MrNV) may also act as immunomodulators against the disease by targeting the viral genes. The MrNV RdRp and capsid protein were able to reduce the viral load after a 14 day post challenge. Sequence similarity in different viral isolates, the nucleotide and amino acid sequence of MrNV capsid gene was studied and compared to Thai, Taiwanese, Chinese and Belize MrNV isolates. The phylogenetic analysis based on the sequence comparison of MrNV capsid gene, revealed that the Indian isolate was close to the Thai isolate when compared to other geographical isolates.

Seribiotechnology

Programme was continued on improvement of productivity, enhancement of silk quality, host-plants interaction and post-harvest processing of silk along with utilization of by-products in sericulture. A new initiative on application of silk protein was undertaken as potential biomaterial.

Significant achievements made are summarized.

Development of improved races of silkworm for enhanced productivity

BmNPV resistant strains of silkworm (*Bombyx mori*) have been developed using marker-assisted breeding jointly at Seribiotech Research Laboratory (SBRL), Bangalore and Andhra Pradesh State Sericulture Research and Development Institute (APSSR&DI), Hindupur. These strains have shown about 40 to 50% survival when challenged with BmNPV as compared to 10% survival in CSR-2 lines of silkworm used as control. Efforts were continued on identification of DNA markers linked to cocoon traits at CSR&TI, Mysore. EST-SNP primers have been identified to be closely linked to the quantitative trait loci (QTL) controlling the filament length and denier traits. Diapause specific genes have been identified in the eggs of multivoltine silkworm (*B. mori*) through suppressive subtractive hybridization at SBRL, Bangalore. Work has been initiated on cloning, expression and characterization of yolk protein receptors from mulberry silkworms (*B. mori*) and eri silkworm (*Samiaynthia ricini*).

Studies on ethology and hybrid compatibility of various ecoraces of tasar

silkworm (*Antheraea mylitta*) have been initiated at Kakatiya University, Warangal. Ethological and morphological characteristics of four ecoraces of tasar silkworm – Andhra local, Daba TU, Daba BV and Bhandara at different stages of life cycle have been recorded.

Efforts were made to develop protocols for cryopreservation of eggs and embryos of silkworm (*B. mori*) at Central Sericultural Germplasm Resource Centre, Hosur. A method for dechorination of silkworm eggs of 10 accessions of multivoltine and bivoltine races has been successfully developed.

Development of Diseases Control Measures

Efforts were continued on biochemical and molecular characterization of events following uzifly infestation of silkworm at SBRL, Bangalore. Immune response proteins such as chaperones, cytokines, signal proteins and proteolytic enzymes in silkworm were identified. Life cycle features of microsporidians infecting tasar silkworm (*A. mylitta*) and muga silkworm (*A. assama*) have been studied.

Improvement of Host Plants

Multiple test mapping populations have

been raised by crossing two powdery mildew resistant and three susceptible parents towards validation and utilization of SCAR marker for powdery mildew resistance in mulberry jointly at CSR&TI, Berhampore and CCMB, Hyderabad. A novel AP2/ERE BP family surface wax-related gene called *MiSHN* has been cloned and characterized from mulberry jointly at University of Agricultural Sciences, Bangalore and CSR&TI, Mysore. Over-expression of *MiSHN* cDNA in tobacco (*Nicotiana tabacum*) resulted in an increase in leaf surface wax leading to delayed post-harvest water loss.

A consortium project on Mulberry Genomics (CPMG) involving four institutions – CSR&TI, Mysore, CSGRC, Hosur, UAS, Bangalore and UDSC, New Delhi has been continued. Genotyping of 72 exotic mulberry germplasm using SSR markers has been completed jointly at CSR&TI, Mysore and CSGRC, Hosur. Four mulberry genotypes having high water use efficiency (WUE) and high root growth – UP, MS-3, Himachal local and Dudia white have been selected for transcriptome-based SNP discovery, identification and characterization of novel stress specific genes jointly at UAS, Bangalore and UDSC, New Delhi. Genomic SSR markers have been identified by adopting the microsatellite enrichment strategy in

mulberry at UAS, Bangalore. Mapping populations segregating for root traits and WUE have been established for construction of linkage map in mulberry using the co-dominant SSR markers.

Post-harvest processing of silk

Studies have been continued on two microbial dyes – Bluish Violet and Scarlett Red for their dyeing characteristics and dyeing process optimization jointly at IICT, Mumbai and Bhavan's College, Mumbai. Optimization of dyeing process parameters, dyeing kinetics and improvement of fastness properties through application of mordents of these dyes has been successfully accomplished. Significant improvement in fastness properties have been achieved with mordenting of silk fabrics.

Utilization of by-products

Process for recovery of sericin from the soap alkali as well as from industrial silk degumming liquor has been standardized at pilot plant set up by IIT, New Delhi jointly with an industrial partner. Application of sericin on polyester fabric has been found to impart value-added properties to the finished product such as improved moisture regain, antistatic behaviour, antibacterial and ultra-violet protection.

Silk Proteins as Potential Biomaterials

Silk based supermacroporous cryogel matrices have been synthesized by cryogelatin technology for exploring their potential in cell-material interactions at IIT, Kanpur. Silk fibroin-agarose cryogel composites showed fast swelling kinetics, high-water uptake and good flow rates. These have shown good cell attachment and proliferation properties during interaction with fibroblasts. Efforts have been initiated on utilization of commercial silk waste as potential nano-biomaterial at RV College of Engineering, Bangalore. Process for extraction and preparation of nano sericin material has been standardized.

Basic Research in Modern Biology

The department through basic research programme in Modern Biology has been supporting a number of research projects to increase the basic competency of basic research. Important leads obtained in many of the basic research studies led to strengthening of applied research and better understanding of the basic principles. A number of research programs were supported during the period. Noteworthy achievements of some of the projects are presented below:

Bacterial/Microbial Functional Genomics

Studies conducted by researchers in BHU showed the role of anti-ant sigma factor in conferring resistance to several cell wall active antibiotics including first, second and third generation cephalosporins indicating novel mechanisms of antibiotic resistance in bacteria.

At DU South Campus functional expression of full length channel rhodopsin in yeast expression system was reported. Further work is being carried out to elucidate the spectral and structural characteristics of the light-gated ion channel protein.

Work conducted by scientists at IISc has shown a single mammalian mitochondrial translation initiation factor to functionally replace two bacterial factors (IF1 and IF2). Leads showed that the ribosome recycling factor (RRF) known to disassemble post-termination complexes contributes to recycling of ribosomal complexes stalled at the step of elongation in *E.coli*.

Cellular and Molecular Immunology

Studies were conducted on the expression and function of nucleotide binding oligomerization domain proteins in macrophages on treatment with peptidoglycan at BHU. The findings

revealed that PGN induced iNOS expression in mouse peritoneal macrophages is a secondary effect in which PGE2 plays an important role along with other autocrine/paracrine signaling molecules such as IFN α , TNF α , INF α .

In a study carried out to investigate chronic inflammatory disease like arthritis at Vittal Mallya Scientific Research Foundation has led to the first time report to relate and establish involvement of NFkB induction to other cytokines in IL-1 signaling in human synovial sarcoma cell lines

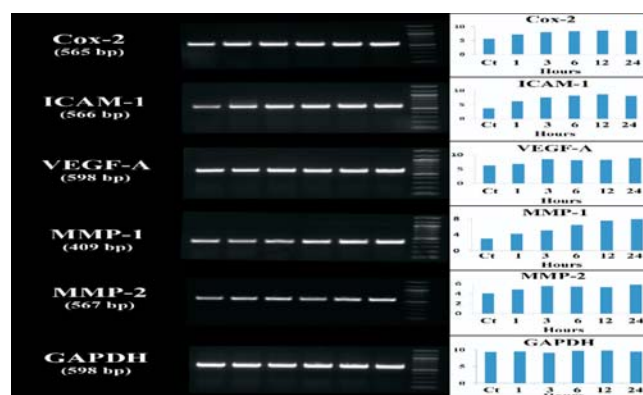


Fig.4.18: RT-PCR analysis raise in different cytokines (Cox-2, ICAM, VEGF, MMP-1 and MMP-2 after NFkB activation indicating inflammatory from synovial sarcoma cells treated with IL-1 for 1,3,6,12 and 24 hours (GAPDH-internal Control)

Structural Biology

Scientists working on structural and functional aspect of calcium sensor proteins from *E.histolytica* at JNU have shown the three dimensional solution structure of

EhCaBP3 using solution NMR. The structural analysis showed that this protein is partially folded with a well folded N-terminal domain and an unstructured C-terminal counterpart. Structural studies carried out at IISc Bangalore on acetate kinase (AcKA) which shares homology with PduW and TdcD have led to the identification of a novel ligand pockets which could be important for enzymatic regulation.

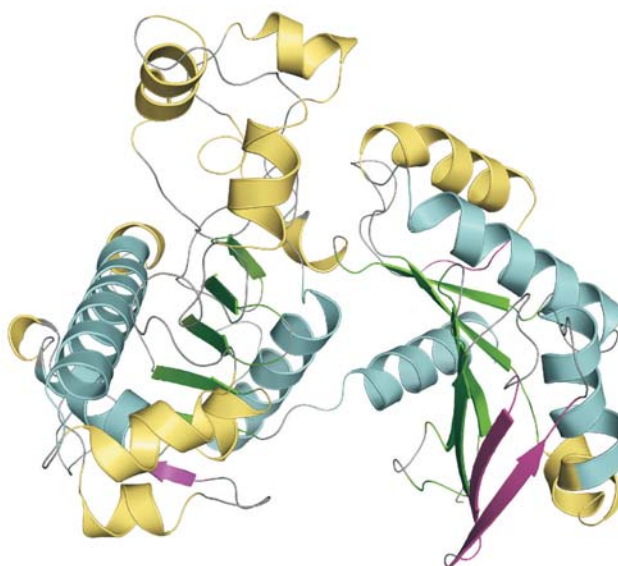


Fig. 4.19 : Tertiary structure of *S. typhimurium* AckA illustrating the small (domain-I) and large (domain-II) domains of *StAckA*. The core secondary structural elements (ââââââââ) are shown in green (strands) and cyan (helices), while insertions of subdomains between secondary structural elements are highlighted in magenta (strands) and yellow (helices)

Scientists working at ACTREC, Mumbai on structural and functional characterization of RAP80: a novel h-BRCA1 interacting protein involved in the mediation of DNA damage

repair have reported change in the protein folding of RAP80 wt, BRCA1 wt and pathogenic mutants. The information is being generated for further determining the residues important for genomic integrity and for drug discovery.

Cell and Molecular Biology

Work undertaken to functionally characterize HAMP domain in osmosensing at IMTech, Chandigarh have shown that HAMP domain is crucial for osmosensing by DhNiklp (group III hybrid histidine kinase) and regulates the activity of DhNiklp like “on-off switch”. Their work has provided an insight into the molecular mechanism of osmosensing by hybrid histidine kinases. Overexpression studies conducted on the role of the molecular chaperone protein DNAJB6 at IISc, Bangalore showed isoform 2 in the cervical cancer cell line Hela increased the rate of cell proliferation, suggesting that it could be involved in the tumor development and progression.

Scientists at IISc Bangalore have reported a distinct function of *FANCO/RAD51C* gene in DNA damage signaling and repair. In addition, they have also shown that ATM and ATR whose mutations are known to cause ataxia telangiectasia and ATR-seckel syndrome, respectively regulate sister chromatid recombination, a process involved

in DNA repair. Studies on molecular mechanism of pathogenesis of glaucoma at CCMB have shown that glaucoma associated mutations causes alteration in interaction of optineurin with cellular proteins and this leads to defect in function. Optineurin regulates signaling through transcription factor NF- κ B, by mediating interaction of an enzyme CYLD (deubiquitinases) with its substrate RIP; a glaucoma causing mutant (H486R).

Biochemistry & Biophysics

The group working on elucidating the role of MAP kinase directed phosphatases in Toll-like receptor signaling mediated protective Th 1 type immunity at UCS, Kolkata, have for the first time identified that tumor necrosis factor receptor-associated factor (TRAF)3, a negative regulator of TLR pathway plays a critical role in the establishment of visceral infection.

Work carried out at NII to understand the role of different domains on the stability of interferon- α induced human guanylate binding protein has led to the identification of a novel DxEKGD motif in hGBP1. The truncated and mutant proteins showed that both the alpha helix of the intermediate region and the motif plays critical role in the stimulation of the activity which may be related with antiviral activity of the protein.

Scientists at CCMB working on elucidating the role of inositol pyrophosphates in eukaryotes have shown that yeast lacking IP7 grow slowly compared to their normal counterpart and attribute their slow growth to a decreased role of protein synthesis. Further, the cellular protein synthesis machinery is reduced in yeast that does not have IP7. The work may help in better understanding of mechanism regulating cell growth in all eukaryotes.

Cancer and Tumor Biology

Group working on simultaneous inhibition of plasminogen system along with matrix metalloproteinase in controlling angiogenesis at University of Burdwan have newly synthesized phthalazine compound and platinum-azo compound which can be used as small molecule inhibitor. Isoquinilone another compound synthesized by the same group could be used as imaging molecules for cancer cells.

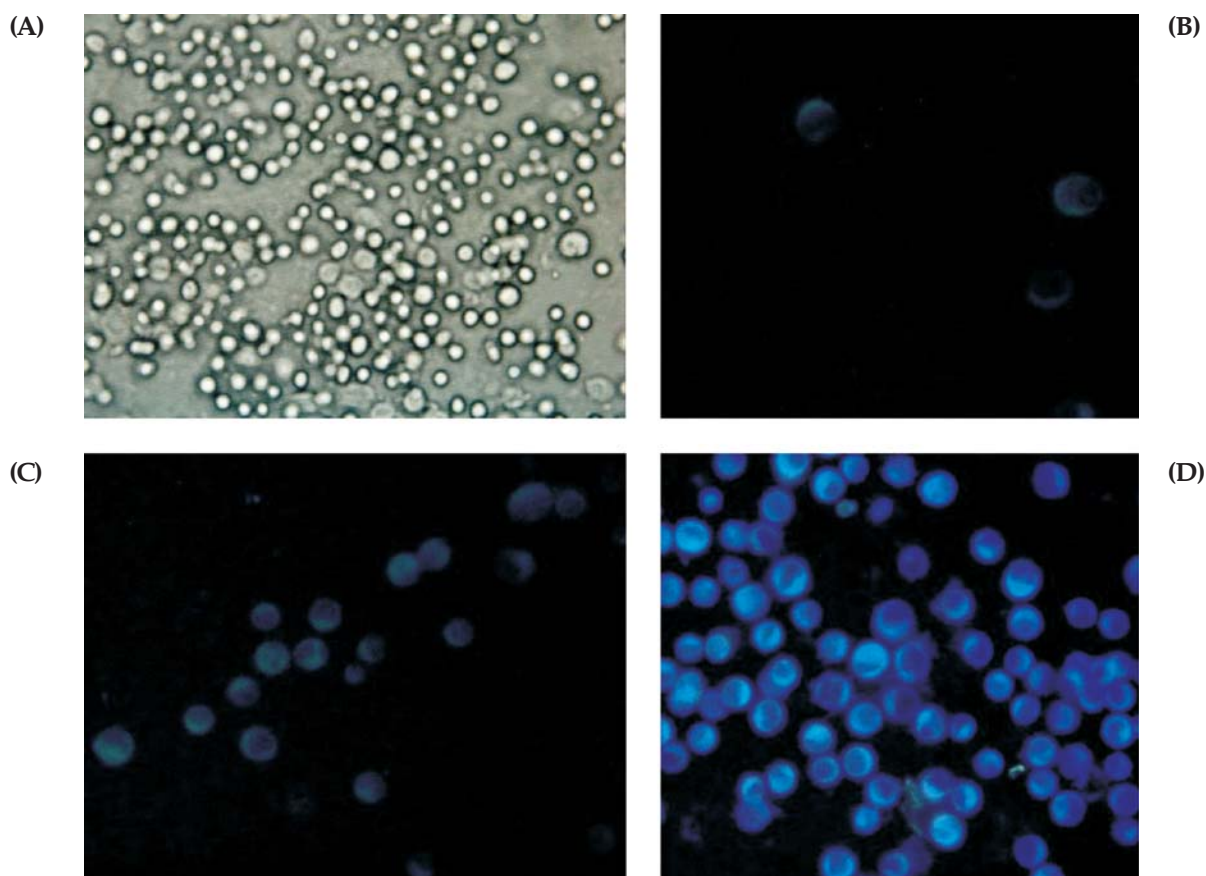


Fig.4.20: Cancer cell imaging with isoquinilone compound under fluorescence microscope. The bright field image [10X objective] of HeLa cells (A) grown in normal culture media and placed on glass slide. The faintly fluorished cells were visible [40X objective], when incubated with only isoquinilone compound (B). The cells were seen to fluoresce with greater intensity in presence of increasing amount of FeCl_3 (C, D).

Studies on characterization of functional interaction between estrogen receptor and ETS transcription factor in breast cancer cells at University of Hyderabad have revealed a positive co-relative expression of ESE1 with ER α in breast cancer patients and showed poor patient survival. It is also shown that ESE1 expression may lead to ER-negative breast cancer phenotype. Further work is being carried out to determine binding regions of these two proteins to design a peptide which can prevent their interaction.

Studies on understanding the effect of statin drugs on breast cancer cells and the mechanism involved in this process have suggested that only hydrophobic statins like fluvastatin, simvastatin selectively cause breast cancer cell death due to statin induced nitric oxide generation via inducible nitric oxide synthase (iNOS). Further, their group has also shown that statin dysregulate iron transport mechanism in cancer cells and thereby lead to cancer cell death. Work done at Chittaranjan National Cancer Institute, Kolkata has revealed that dopamine can significantly inhibit lung tumor growth *in-vivo* and *in-vitro* by targeting tumor blood vessels and its molecular mechanism has been deciphered.

Studies to investigate control of cell-cell adhesion and its relevance to metastatic progression at ACTREC, Mumbai have

shown that loss of cell-cell adhesion leads to change in the level of genes that modify the keratin cytoskeleton. Inhibiting keratin expression leads to a decrease in tumor progression and metastasis, while the altered cytoskeleton seen in tumor cells leads to an increase in metastasis and tumor progression. Therefore modified keratin protein could serve as prognostic markers in tumors.

Developmental Neurobiology

Studies on characterization of topographic guidance molecules in the visual pathway at IIT Kanpur, has led to the identification of candidate molecules that guide the ganglion cell axons to their target during embryonic development. Further work in this area will lead to new regenerative therapeutic strategies for diseases affecting the optic nerve.

Chemical Biology

The investigation conducted at BHU has demonstrated the role of microwave irradiation in the synthesis of novel bioactive heterocyclic compounds resulting in a promising alternative to the existing methods of their synthesis.

Plant Molecular Biology

Under the project on development of virus

resistant papaya crop at Babasaheb Bhimrao Ambedkar University, Lucknow, SiRNA against two major genes i.e. the coat protein gene (AV1) and replicase gene (AC1) of papaya leaf curl virus (PaLCuV) have successfully designed. Further work is being carried out to design SiRNA against geminiviral suppressor genes. Under the project to understand the molecular basis of plant immunity vs. disease at organ level, scientists at NIPGR, New Delhi have developed 2-DE map for nuclear proteome and phosphor-proteome in rice. In chickpea, 2-DE map of ECM proteome has been generated and more than 1000 proteins were found to be up regulated upon fungal infection. These results might help in understanding the stress responsive proteome and identify target proteins and strategies to improve stress adaptation in plants.

Vascular Biology

Investigation carried out to elucidate signaling mechanism of sFRP4 mediated inhibition of angiogenesis at Anna University showed that secreted frizzled related protein 4 (sFRP4) can inhibit angiogenesis under both *in-vivo* and *in vitro* conditions. The excessive leakiness of endothelial monolayer is coupled with increased ROS levels that promote the endothelial cells to undergo apoptosis.

The department has taken initiatives to promote new and emerging areas in modern biology and developed a network program under Systems Biology with focus on resolving and understanding the regulatory dynamics of interaction between *Mtb* and the cellular component of the host using a systems level approach and combining experimental, theoretical and computational approach.

Medical Biotechnology

Infectious Diseases

The Department promoted R&D activities in the area of infectious diseases specifically relevant for the Country caused by various pathogenic agents including bacteria, viruses, parasites, fungi and others. Programs were supported to develop preventive, therapeutic and diagnostic tools for infectious diseases such as Tuberculosis, Cholera, HIV/AIDS, Hepatitis, Influenza, Chikungunya, Malaria, Leishmaniasis etc. During the year, 3 task force meetings were organized and 24 new projects were funded. Significant achievements of some of the R&D programmes are summarized as below:

Bacterial Diseases

Bacterial infections constitute a major cause of mortality in early infancy in our country.

In order to improve the efficacy of standard antibiotic therapy to reduce neonatal and infant mortality a study was supported to evaluate the effect of zinc administration as an adjunct to antibiotics in infants with serious bacterial infection. Oral zinc application has proven to be a promising candidate to improve outcomes of serious bacterial illnesses in new-borns and young infants treated with antibiotics.

In another study supported, a multiplex PCR based detection kit has been developed, validated and patented for the rapid detection of STDs caused by *Neisseria gonorrhoea* and *Chlamydia trachomatis*. Efforts were made towards the technology transfer for commercialization and development of a cost effective indigenous kit. Under the aegis of Infectious Disease area, a LAMP assay has been standardized. The kit was shown to be very sensitive for detecting *Neisseria gonorrhoea* DNA in preparations from cultured bacteria, spiked clinical specimens and real-life clinical specimens.

Viral Diseases

A study was supported to define the mechanism of MAPK/ERK-2 incorporation into HIV and SIV virions and to understand the relationship between MAPK/ERK-2 packaging and HIV/SIV replication both in the dividing and non-dividing target cells.

The data provide evidence that ERK-2 interacts specifically with Gag present in the capsid protein and packaged into virus particles. Further studies on the role of ERK-2 in early activation of NF- κ B in early infection are in progress.

Early pregnancy associated protein-1 (Epap-1), isolated from the first trimester placental tissue, blood and urine of pregnant women during first trimester has been shown to inhibit HIV-1 entry and is found to have affinity to HIV-1 gp120. A study was funded to design effective anti-HIV peptide from Epap-1. Indeed, small peptides derived from Epap-1 showed significant anti HIV-1 activity and further work to design and develop anti- HIV peptides is in progress.

Chandipura virus replicates in nervous tissue and spreads through the neuron to reach brain. Also replication of virus in spinal cord induces tissues damages and immunological reactions. Study concluded that the death in susceptible young mice might be due to spinal cord damage and several immunological reactions in nervous tissues. Pre-clinical studies with potential anti-HIV compound, Acaciaside-B and enriched fraction were conducted for their effects on the several species of vaginal *Lactobacillus* flora and found to be reasonably safe with potent activity.

Inhibition studies of Influenza A virus using Ribozyme and siRNA have shown that siRNA-ribozyme chimeric constructs protect the cells to variable extents against influenza virus infection. Molecular studies on host-virus relationships of Swine-flu (H1N1) and Avian influenza (H5N1) viruses have shown that interference using siRNA to the host cell partner protein in the interaction of viral neuraminidase (NA)-host cell adhesion molecule-6 (CD66) caused reduced viral transcription and increased cell apoptosis. Diagnostic tool for dengue infection, a rapid IgM ELISA assay has been developed and validated. A serum bank of dengue infected patients has also been generated. Clinico-pathological study of arthropathy and acute flaccid paralysis following Chikungunya virus infection revealed high levels of MCP-1, a chemokine associated with bone degeneration, in serum of infected patients.

Parasitic Diseases

Studies on novel anti-leishmanial agent against experimental visceral leishmaniasis suggested that chromosome linked nitronone can function as an important immunomodulator even in an immune-compromised state. The data suggest that chromosome-linked nitronones are the class of compounds with potential for further development for anti-protozoal therapy. In

another study, Iridoid glucosides are identified as novel inhibitor of Trypanothione reductase from an Indian Medicinal Plant *Nyctanthes arbortristis*. Iridoid glucosides were assayed for anti-leishmanial activity with promising results.

Acaciaside A from *Acacia auriculiformis* has been identified as a novel compound for the control of bancroftian filariasis. Acaciaside A is shown to induce apoptosis in *Setaria cervi* cells by different pathways involving up-regulation of different pro-apoptotic genes and down-regulation of some of the anti-apoptotic genes.

DBT-ICMR Collaboration

DBT-ICMR collaborative programme on “HIV/AIDS and Microbicides” was implemented for basic and translational research on immunopathogenesis of HIV and development of therapeutic strategies. It has played an integral role in supporting the transition of anti-viral candidates from early discovery to initial clinical testing. The 2nd phase of the programme has been announced aiming at accelerating research that will generate knowledge and develop state-of-the-art technologies to provide the basis for the development of HIV vaccines and novel therapies against HIV including microbicides.

HIV/AIDS

In order to neutralize diverse HIV isolates, *E coli* expressed Outer Domain based immunogen (ODEC) has been shown to be highly immunogenic which resulted in neutralization of B and C subtypes. Similarly CD4Bs, a gp120 based fragment, was found to elicit better neutralization than gp120. Attempts are being made towards patenting the CD4Bs immunogens.

Indian clade C envelop chain isolated from recently transmitted HIV-1 showed moderate sensitivities to variety of antibodies including broadly neutralizing monoclonal antibodies. Novel residues in clade C HIV-1 Env were found to confer enhanced virus neutralization by acting on different sites on Env. A new class of specific and tight binders that inhibit Rev-RRE interaction in HIV were synthesized. A novel dual reporter based single step assay system has been developed for evaluation of drugs that inhibit Rev-RRE and Tat-TAR interactions that can lead to development of inhibitors of HIV replication. Novel nucleobase ethers such as glycol and propylene glycol nucleobase ethers that bind with bulge and loop region of TAR RNA have been synthesized.

A Virtual Knowledge and Resource Centre is functional at NARI, Pune. Fifty eight

participants have registered at website to provide a list of reagents and antibodies available with them. Various institutes have developed protocols, assays, cell lines from peripheral blood mononuclear cells, complex mobility analysis, biological isolation of HIV from semen of HIV-infected individuals, purification of Tat protein and its functional aspects.

Microbicides

Several chemically synthesized reverse transcriptase inhibitors have shown potential to develop as anti-HIV molecules. Recently identified Rabbit epididymal haemoglobin beta peptide (REHb β P) with antimicrobial/anti HIV-1 properties has been filed for patenting. Compounds from different plants sources exhibited promising anti-HIV activity. BASANT, a polyherbal gel, used as a vaginal microbicide showed promising results in terms of safety and acceptability among women in phase-1 clinical trial. Potential anti-HIV compounds from various plant extracts have been identified using various standardized assays *in vitro* at NII, New Delhi.

DBT-IAVI Collaboration

The collaborative programme has been further extended for another period of 5 years under the aegis of Indian Medicinal

Chemistry Programme. Two projects have been funded at ICGEB, New Delhi to study the development of conformationally preferred peptide immunogens as candidates against HIV-infection. The emphasis is on designing peptide immunogens to elicit HIV-1 neutralizing monoclonal antibodies. At IISc, Bangalore the study is directed towards designing and characterization of novel Outer Domain (OD) derived immunogens with additional mutations to prevent protein aggregation.

Chronic Disease Biology

There is a greater emphasis on the chronic disease area. There are about 120 ongoing projects in the area covering patho-biological aspects of various cancer, pathway discovery,

drug-interventions, biomarkers etc. The Curcumin clinical trials in cancer have reached a critical stage. DBT had set-up a “Curcumin Clinical Pharmacology Lab” at ACTREC, Mumbai for pharma-cological assessment of Curcumin & its metabolites in serum/plasma of patients on Curcumin intervention. The first lot of analysis has been done. The trials on oral-pre-cancer lesions have been completed and several meetings of the Data Safety Monitoring Board taken place to firm up SAP. The data captured and cleaning is going on.

A Cancer Data been has been created by IOB, Bangalore which encompasses all important and relevant information about DBT's stake in the cancer domain. It can be accessed though http://www.increddb.org/dbt_home.html.

India Cancer Research Database

Home | Browse Investigators | DBT Cancer Biology | FAQs | Contact Us

About the Database

India Cancer Research Database (ICRD) provides details of scientists and physicians involved in cancer research in India along with information about their areas of expertise and research, publications and funded grants. The goal of the database is to foster collaborations among researchers and to provide a snapshot of the ongoing research initiatives and activities in India.

Name :
 Affiliation : [See List](#)
 Specialization : [See List](#)
 Neoplasm : [See List](#)
 State : [See List](#)

Call for Research Proposals

- Call for Proposals for funding support 17th Batch under SBIRI
- Call for Proposals-under BIPPBIRAP
- Call for Concept Notes for Research Proposals on Biotech Product and Process Development
- Call for Proposals for Rapid Grant for Young Investigators (RGYI)-2011

Announcements

- October 27-30, 2012 3rd International Conference on Stem Cells and Cancer (ICSCC-2012): Proliferation, Differentiation and Apoptosis, Pune, Maharashtra
- January 26-29, 2012 International symposium on Cancer Genomics and its Impact in the Clinics, Navi Mumbai
- December 13-16, 2011 New Horizons in Cancer Research: Biology to Prevention to Therapy, Gurgaon, Delhi

India Cancer Research Database has been developed by the [Institute of Bioinformatics](#) with funding from the Department of Biotechnology, Government of India.

Fig. 4.21: Indian Cancer Research Database

Neuroscience

The DBT had established an Expert Group on Neurobiology under its Task force on Chronic Disease Biology (EGN-CDB). The EGN-CDB is making efforts to put more thrust in the area of Neurosciences research in the country, with its call for proposals, advertised in the April, 2010 followed by a fresh RFA in September, 2011. More than 100 projects have been funded covering various aspects of neuroscience. A dedicated website for neuro-projects has been prepared; and relevant information pertaining to DBT's activities in neuro-area is available at dbt-neuro.ncbs.res.in hosted by NCBS, Bangaluru.

Endocrine, Cardiac, Autoimmune Diseases & Reproductive Biology

A strategy meeting was held to provide more impetus to the area of "Endocrine, Cardiac, Renal, Autoimmune Diseases & Reproductive Biology" under Chronic Disease Biology. Call for Proposals for Kidney Diseases and Autoimmune Disorders were released during the year and about 40 projects shortlisted for final round of examination. A brain-storming on Rheumatic heart disease was held. The general consensus was that despite a belief that RHD is not a disease of public health concern; the prevalence rate was high

amongst school going children. The Department is also planning to invite proposals in the area of Diabetes soon.

Up-gradation of Infrastructure in Medical Colleges in the NER

The DBT program on Development/Up-gradation of Infrastructure in Medical Colleges in the NER was started in the year 2009. The program is now operational in 12 medical colleges/ institutions in four states of the Region, namely Assam, Nagaland, Tripura and Manipur. Labs of 21 Principal Investigators have been renovated / upgraded for carrying out quality research on various health problems prevalent in the region using modern biotechnology tools and technologies. Various scientific equipments including 27 high cost equipments such as flow cytometer, Real-Time PCR machine, Hi-speed centrifuges, -80 freezers etc. have been procured and being installed. Several of these labs are now ready for formal inauguration.

Nephrotic Syndrome

The Department has funded a project to explore the pathogenesis of idiopathic nephrotic syndrome of childhood. Leads from this study are likely to provide evidence for cytokine polarization of T-helper cells. On the long-term, this study

might contribute to discovery of a biomarker for the Nephrotic Syndrome disease course.

Hemolytic Uremic Syndrome

A project was pursued to determine the presence of autoantibodies against factor H in Indian children with Hemolytic Uremic Syndrome and their relation to disease severity and course and to characterize the antibodies devise better treatments for the future.

Celiac Disease Project on Diagnostics

A project on towards the development of a rapid, indigenous test for diagnosis of celiac disease was undertaken and an ELISA KIT has been developed. The Kit has been tested against well-characterized sera samples and also on sera collected from children diagnosed with celiac diseases. The samples tested and compared with other commercially available ELISA kits and the Kit is found comparable with the best imported Kit available in the market and is ready for commercialization. Development of Dip-stick that would contain all the three antibodies (IgA, IgM, IgG) for detection in fresh human blood samples progressing well.

Vaccine Research and Development

The Department has taken collaborative effort between Translational Health Science and

Technology Institute (THSTI) and International AIDS Vaccine Initiative (IAVI) to accelerate the HIV Vaccine discovery program. The program is targeted to expand the number of vaccine candidates globally for testing, and development. The programme shall engage scientists, build scientific capacity in India towards enhancement of global R&D efforts for HIV vaccine development, strengthen efforts to share and commercialize scientific knowledge and foster inclusive innovation process. The unique industrial-type high-throughput vaccine design, screening and selection processes proposed for the THSTI-IAVI HIV Vaccine Lab will be largely facilitated by interdisciplinary interaction driven by the principles of international collaboration, high-quality science and vaccine-oriented research.

Biotechnology Strategic Planning and Analysis Centre (Bio-SPACE)

The Department has supported this centre with a DBT-ICGEB collaborative effort with the primary emphasis to address issues related to healthcare biotechnology, perform technology assessment in order to bring out appropriate strategic plans relevant for the country. In addition the centre would take up work on evaluation of intended efficacy of new technologies which could range from disease burdens of neglected diseases, newly diagnosable chronic ailments, likely future

impact of drug resistant diseases, increased incidence of diseases due to climate change, faster industrialization and lifestyle changes such as diabetes, cancer, and respiratory diseases.

Biomedical Genomics Centre at IPGMER, Kolkata (BMGC-K)

The Department has also supported BMGC-K at Kolkata with “precisely defined” on disease phenotypes, including events resulting from administration of relevant drugs, drawn from the patient population of the Medical School and to return back to the patients with genomic solutions for improved diagnosis, management and prophylaxis. This centre will act as a platform for clinical scientists to carry out research in genomics. In addition, it also undertakes various events viz. workshops and CME courses on biomedical genomics, with the eventual goal of initiating a DM/DNB programme on Medical/Clinical Genetics and impart clinical services for detection of genetic disorders and their management, thus BMGC-K will foster capacity-building that is sorely lacking in medical profession at present.

Advanced Technology Platform Centre (ATPC), Faridabad

An advanced Technology Platform Centre

(ATPC) is supported to promote multidisciplinary research that translates scientific and technological advancements into innovations towards improvement of public health. It would act as a catalyst for multidisciplinary basic and translational R&D by providing relevant state of the art instrumentation, and professional services for research laboratories at the Biotech Science Cluster (BSC) Faridabad, viz. Regional Centre for Biotechnology (RCB), Translational Health Science & Technology Institute (THSTI) etc. In addition, it would also promote industry-academia participation and training of personnel at different levels.

Stem Cell Research

The Department is promoting basic and translational research in the area of stem cells and regenerative medicine in the country since 2001 keeping in view its potential therapeutic applications. A number of programmes on various aspects of embryonic and induced pluripotent stem cells have been implemented for basic and clinical research using adult stem cells. Currently, over 45 institutions, hospitals and industry are involved in stem cell research in the country. An institute for Stem Cell Biology and Regenerative Medicine has been established at Bangalore with its translational units at Christian

Medical College, Vellore. GMP and clean room facilities have been established in various medical schools. The Centre at Vellore is a dedicated Center for translational stem cell research in a medical environment established within an academic medical environment with several basic and clinical (physician) scientists involved in stem cell research. Three young scientists were sent for long training on DBT overseas scheme in top laboratories in USA for specific areas of application to be developed at Centre. The work involves: AAV based gene therapy, endothelial progenitors de novo and iPS derived in MGH, studies on the hematopoietic stem cell niche.

Embryonic and induced pluripotent Stem Cells

Embryonic stem cell lines generated from discarded grade III blastocysts at JNCASR, Bangalore and deposited in the UK stem cell bank are being used by the national and international scientists for research purposes. During the period, a number of programmes have been generated and implemented on various aspects of embryonic stem cells and induced pluripotent stem cells (iPSCs). Some of the programmes are: generation and characterization of iPSCs; analysis of human amniotic membrane mesenchymal stem

cells; differentiation of human mesenchymal stem cells to cardiomyocytic and adipocytic lineage *in-vitro*; AAV-based vector technology on induced pluripotent stem cells, etc. In addition to R&D programmes, training programmes and workshop on iPSCs have also been supported during the year. Programmes have been formulated in the area of adult stem cells and sanctioned for implementation.

Clinical Research

The Department has implemented multi-centric, multi-investigators clinical trials in the areas of acute myocardial infarction (AMI), acute ischemic stroke (AIS) and critical limb ischemia using autologous bone marrow adult stem cells. Recruitment of 250 patients (125 control group and 125 intervention group) in AMI clinical trial and 120 patients (60 control group and 60 intervention group) in AIS clinical trial have been completed. A clinical trial proposal has been implemented to assess safety and efficacy of adult autologous peripheral blood cells in critical limb ischemia. Patients are being recruited at four hospitals in the country. The sample size of the study is 200 (100 in the intervention arm and 100 in the Control arm). Follow-up of the recruited patients under this study is being carried out by all the participating centres.

Guidelines for Stem Cell Research and Therapy

In order to revise the guidelines for stem cell research and therapy formulated jointly by the Department and Indian Council of Medical Research (ICMR), public consultation in northern region were organized in December 2011. The inputs/opinion received from all the stakeholders during public consultation organized in east, west, south, north-east and northern regions will be taken into account during revision of the guidelines.

Bioengineering

Bioengineering is a fusion of engineering sciences with life sciences for promotion of scientific discovery and the development of new biomedical technologies and therapies through research and education. Under this scheme, the Department has laid emphasis to develop bio-based technology involving interdisciplinary sciences towards development of novel materials, designing new devices, establishing new methods for disease diagnosis, developing new computational approaches to create biological system etc. During this period the Department received 160 proposals out of which 25 proposals were found worthy of financial support and 60 proposals are under processing for further consideration

by the Department. Significant achievements of some of the projects are presented below:

Bio-imaging/Instrumentation

Scientists at IIT Kharagpur are aiming to investigate the biomechanical factors responsible for loosening and eventual failure of an implant, using numerical (Finite Element Analysis), and experimental techniques. The primary goal of the project is to develop better orthopaedic implants. The study is mainly focused on lower limbs, like the hip and the knee joint replacements. This study sought to explain the relationship between load transfer and some biomechanical failure mechanisms in femoral head resurfacing, using FE analysis and experimental measurements, in order to suggest measures for improved femoral resurfacing implant.

Scientists at BITS, Pilani are making effort to develop a novel microscopic technique based on photothermal detection of metallic nanoparticle labels. The “photothermal microscope” contributes to the area of biomolecular imaging and tracking. The study would provide insight on transport mechanisms of DNA through the nuclear pore complexes and its internalisation in the nucleus, with potential implications in

gene therapy. Gold nanoparticles are detected by sensing intensity changes of the probe beam using a Lock in amplifier. Labeling of DNA is done with different dye molecules and gold nanoparticles. Once the detection scheme is optimized to detect and image gold nanoparticle labeled biomolecules, it will provide a novel microscopic technique free of photo bleaching.

Scientists at IIT Kanpur have developed a mechanistic model for predicting growth of aneurysms in an arterial bifurcation. The investigators have developed a numerical simulator for oscillatory flow in arterial bifurcation. Simulations have been carried out with the following features a.) adaptive high quality mesh generation for FVM calculations, b.) computational fluid dynamics calculations over unstructured meshes, c.) data analysis, extraction of physiologically meaningful parameters and d.) tools for visualization of the results.

Biomaterial

Scientists at IVRI, Izzatnagar have developed novel intelligent peptides for targeting PNA into cell and see their antiviral efficacy to develop non-invasive antisense therapeutic intervention. They designed and synthesized PNA for fusion F-gene of NDV and evaluated them by

targeting into in vitro virus cell culture system. Peptides having rabies virus glycoprotein motif with NLS sequence have been designed and their delivery are seen in nerve cell (N₂a cell line) to develop tissue specific novel peptides for targeting PNA particularly CNS across BBB. The investigators found that PNA uptake is significantly higher in N₂a cells and in primary cells of mouse brain in comparison to primary cells of liver, spleen and kidney. The identified peptides as molecular steering for brain homing along with efficacy of PNA as antiviral are underway for the in vivo studies.

Scientists at IIT Madras are in the process of investigating simultaneous release of antibiotics and anti-inflammatory drugs using CDHA nanocarriers. CDHA nanocarriers of different Ca/P ratios are synthesized and characterized. The loading and release profiles of two drugs, an antibiotic tetracycline and anti-inflammatory drug ibuprofen have been studied along-with doxycycline and cefalexin. The nanocarriers exhibit both single and two stage release profiles of doxycycline depending on the Ca/P ratio of CDHA.

Tissue Engineering

Scientists at IIT Kanpur and ILBS, New Delhi

aims at developing a liver assist device for the temporary treatment of patients with acute and acute on chronic liver failure. The treatment with this device may help bridge the acute crisis and help spontaneous hepatic regeneration. The anticipated product will be a suitable polymeric bioreactor immobilized with appropriate hepatocytes and cryopreserved for ready application. A suitable polymer based on poly (N-isopropylacrylamide) and chitosan have been synthesized as cryogel scaffold. Bioreactor models in the form of cryogel sheets have been fabricated. Detailed analysis and physico-chemical characterisation of the cryogels based on a number of parameters have been carried out to establish swelling kinetics, porosity, flow rate, protein diffusion and absorption. Efforts at identification and optimisation of cell lines as potential sources for the Bioreactor are in progress.

Scientists at IVRI Izzatnagar, are working on the development of 3-D acellular dermal matrices for reconstructive surgery and evaluate the surgical potential and efficacy of 3-D matrices in laboratory animal models. Different protocols for de-epithelization have been optimized in rabbit, goat, pig and rat. The in vitro cultured primary chicken embryonic fibroblasts and primary mouse

embryonic fibroblasts are seeded on the acellular dermal matrix scaffold and 3D growth of cells has been observed. The histological and scanning electron microscopic examinations have been performed for the morphological assessment of cellular growth on biomaterials. The cell seeded 3D biomaterials would be used for reconstructive surgical applications in the experimental animal models, wherein the wounds will be created in the laboratory animals and will be implanted with cell seeded biomaterials for achieving early healing.

Scientists at Amrita Centre for Nanosciences aimed to develop alginate, chitin and chitosan bandages based on hydrogels with non-toxic ZnO/Herb *Hemigraphis Ulternata* nanoformulations for wound dressing applications. The investigators developed flexible and microporous chitosan hydrogel/ nano zinc oxide composite bandage (CZB) by the incorporation of zinc oxide nanoparticles (nZnO) into chitosan hydrogel. The prepared nanocomposite bandages have been characterized and properties like swelling, degradation, blood clotting, antibacterial, cytocompatibility, cell attachment and infiltration ability of the prepared nanocomposite bandages are been evaluated.

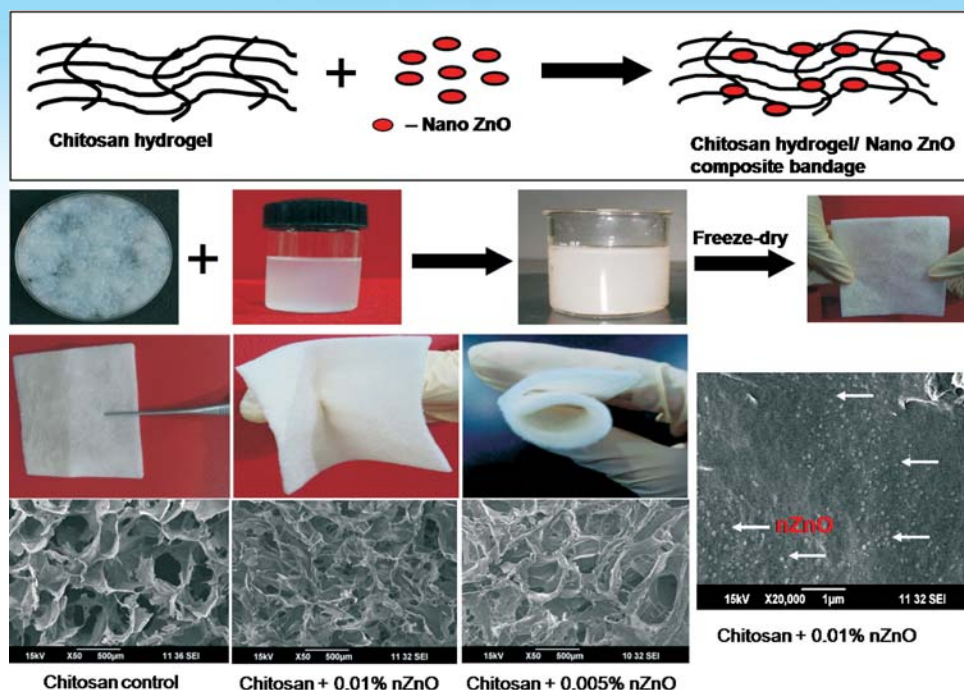


Fig. 4.22: The nanocomposite bandage showed enhanced swelling, blood clotting and antibacterial activity. The study strongly encourages the use of these CZBs for burn, chronic and diabetic wound infections.

Biosensor

Scientists at IACS, Kolkata developed a sensitive and robust cantilever nanosensor for genomic research. The study envisages the systematic development of films of alternative nucleic acids, e.g., the peptide nucleic acid (PNA) and locked nucleic acid (LNA)], onto a solid substrate and assessment of DNA detection capabilities of these layers in comparison to a DNA film. The investigators have optimized the ordered arrangement and the most upright molecular configuration as per requirements of an effective biosensor surface. It is found that such a layer is capable of much superior DNA detection capability in terms of

complete match as well as single base mismatch detection, compared to DNA. It has been found that the LNA-based DNA detection exhibits the highest sensitivity in single base mismatch discrimination.

Scientists at IIT Kharagpur are designing a digital and plug-based microfluidic system to study the aggregation kinetics of the α -amyloid peptide in presence of electric field, chemical molecules and metal ions. The investigators made i) plug based studies in microchannels and ii) droplet based digital microfluidic systems towards the development of microfluidic systems. The microchannels are fabricated by standard soft lithographic technique.

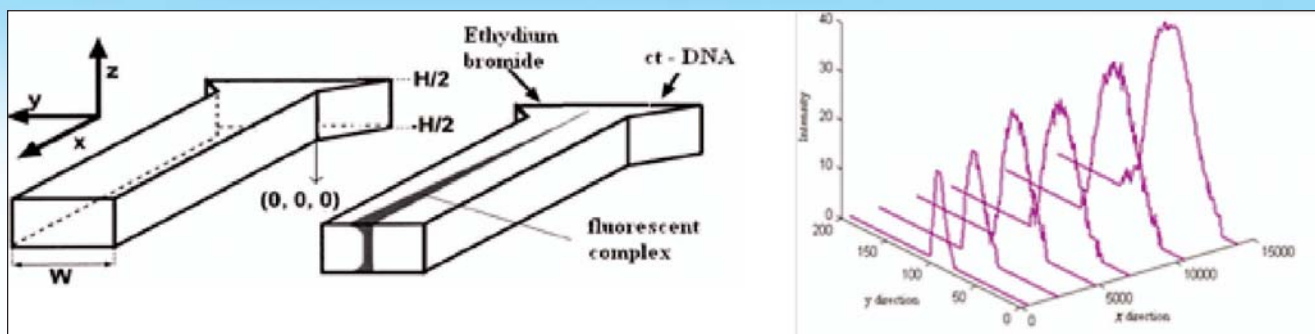


Fig. 4.23 : (a) Schematic of the experiment used to investigate the diffusive broadening in laminar flow of ctDNA and EtBr. (b) The concentration of the fluorescent product was plotted as a function of both y and x direction, indicating enhanced diffusive mixing and product formation along the length of the microchannel.

Digital microfluidics utilizing electro-wetting-on-dielectric (EWOD) has been developed to handle and manipulate discrete droplets rather than a continuous stream.

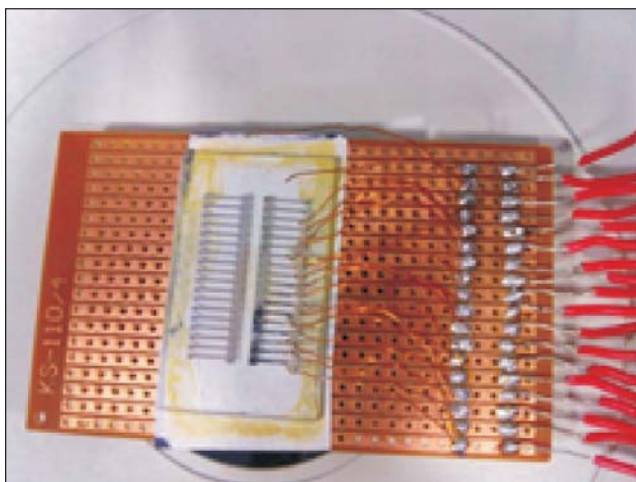


Fig. 4.24: Droplet based digital microfluidic platform

Human Genetics and Genome Analysis

The Human Genetics and Genome Analysis programme that was initiated two decades ago has revolutionized research in the field.

Major projects have been initiated involving clinicians, molecular geneticists and anthropologists. India's rich genetic resource is being utilized to develop baseline data on various ethnic groups for disease susceptibility and provide genetic services to large number of families including prenatal diagnosis and counseling to affected families including tribal population and awareness among public regarding prevalence of common genetic disorders in the country like thalassemia, DMD, SCD, haemophilia etc. The department has focused on disease based human genome analysis program by setting up genetic clinics. Anticipating that the HGP data will be available in public domain, DBT is prudently using its funds to initiate project with major relevance in post genome era. With this in view, major infrastructure has been established at various institutions to undertake advanced genome research including sequencing projects.

Significant achievements made under R&D projects

At M. S. University of Baroda, work on analysis of possible genotype - phenotype correlation between oxidative stress related genes polymorphisms and Vitiligo was funded. The study revealed a significant increase in SOD1 and SOD2 activities concurrent with a significant decrease in CAT, GPX1 and G6PDH activities in vitiligo patients as compared to controls. The GPX1 T/C exon 1 (Leu6Pro; rs4991448) and G6PD G/C exon 2 (Gln41His; rs1050827) SNPs were significantly associated with vitiligo. Study at University of Hyderabad demonstrated for the first time show that PfMre11 is an authentic DNA repair protein of the protozoan parasite *Plasmodium falciparum*. Lack of sequence identity between PfMre11 and human Mre11 indicates that this DNA repair protein is a promising candidate for chemotherapeutic intervention.

Under a project on Congenital Adrenal Hyperplasia (CGA) implemented at AIIMS, New Delhi, 49 patients were diagnosed to have SV CAH type, 12 patients were diagnosed to have SW CAH type and 2 were diagnosed to have non classic type of CAH as per their clinical and hormonal profile. Among these sixty three CAH patients, fifty six (88.89%) had ambiguous

genitalia. Genotype analysis led to the identification of mutations indicating that the patients had abnormal genotype. Further the mutation varied with the type of CAH in patients.

At CDFD, Hyderabad the group standardized the process of transformation of human lymphocytes using Epstein Barr virus obtained from B-95 marmoset cell line and revival of frozen cell lines. In addition the group were able to establish cell lines from 8 patients with rare genetic disorders with future plan to establish more cell lines from additional patients with rare genetic diseases.

Under the project study on "Sperm Factors (DNA damage, mt mutations, oxidative stress) - Role in Recurrent spontaneous abortion (RSA)" at D/o Anatomy, 30 idiopathic RSA cases showed the association of increased ROS level and DFI. Along with ROS study the DFI in such cases was also found to be higher in comparison to controls and the study concluded that male factor especially paternal DNA, do play a role in embryonic and fetal development and loss of DNA integrity may lead to RSA.

In a project on "Biochemical and Functional Characterization of RIO kinase(s) from *Plasmodium falciparum* as Potential Drug Target" at IIT, Guwahati, 3-D model of the

PFD0975w was prepared and critical amino acids for kinase activity and auto-phosphorylation were identified. The group cloned PFD0975w from *Plasmodium falciparum* to over-express the protein in *E.coli*. Efforts to design high resolution horizontal PAGE for non-radioactive protein kinase assays are underway.

At ILBS, Delhi studies were undertaken on “Early prediction of interferon responsiveness in patients infected with Hepatitis C virus (HCV) using pharmacogenomic tools”. Patients have been enrolled for interferon induced gene expression analysis and HCV RNA detection before and after IFN therapy was done. The response rate to IFN therapy in HCV infected genotype1 patients was 55-60%, while in genotype 3 patients it was 90%. Further the group selected 36 genes for gene expression profile based on interferon signaling and other related pathway. Analysis of these gene showed an altered gene expression profile of IFN-induced genes, cytokines (interleukins), SOCS, apoptotic and other related gene in the HCV infected follow up patients on PBMCs at day 0, 1, 4, 7, 14, 28 and at weeks 8, 12, 24.

At IIT, Mumbai under the study on proteomic analysis of human gliomas for biomarker discovery database entitled “TMH Hospital’s Patient Database” to store

the details of the all clinical samples was created. Other databases have been created to document clinical and consumption details of clinical samples, as well as the experimental details of the proteomic study.

Under the project on End Stage Renal Disease (ESRD) at SGPGIMS, Lucknow, the group collected 368 patients and their donors who have reported for the 1st cross match with this group, and also collected 400 unrelated individuals from that region of UP to study the population stratification. Standardization of protocols and population stratification was done with the aim to start the patient and donor KIR genotyping and get more insight into the molecular profiling of KIR and their clinical relevance to the end stage renal disease (ESRD) and graft function after renal transplantation.

Under project on construction of genomic library of *Leptospira interrogans* serovar *Autumnalis* for the identification of immunogenic proteins and development of DNA vaccine, the group at Bharathidasan University constructed and screened the phage library and identified two clones that have showed good sensitivity and specificity and are expected to be an immunogenic gene plays a vital role during infection.

At MAMC, Delhi, group working on lysosomal storage disorders project study,

standardize the gaucher enzyme assay and Mucopolysaccharidoses (MPSI) on dried blood spot using fluoroimmuno assay. This recently gained expertise will help centres in remote areas to send samples to lab on filter paper and the gaucher disease can be diagnosed. The group has also done the detection of beta- Glucosidase enzyme for gaucher disease and Alpha-L-iduronidase enzyme for MPS I on dried blood spots first time in India using the Fluroimmunoassay system and have been cross checked by Traditional Fluroassaytechniques. The current technique is much more accurate and sensitive showing strong correlation co-efficient (R^2) indicating excellent ability to differentiate between healthy controls and affected.

International Cancer Genome Consortium (ICGC) Programme

India is a part of Human Cancer Genome Project – an International Collaborative Initiative (TCGA)“ launched in November, 2008 with commitments of eight countries i.e. India, Australia, Canada, China, France, Japan, Spain and United Kingdom alongwith eleven funding organizations to generate comprehensive, high-resolution analyses of genomic changes for 8 forms of cancer found across the planet based on the International Cancer Genome Atlas programme implemented by National Cancer Institute of National Institute of

Health (NIH), USA. DBT implemented major programme on Oral Cancer, most prevalent form of cancer in India, at National Institute of Biomedical Genomics (NIBMG), Kalyani, in collaboration with Advanced Centre for Research, Treatment and Education on Cancer (ACTREC), Mumbai. So far, whole-exome data on 34 pairs of patient samples has been generated. The analysis of 30 pairs of samples has been completed and all inherited (germline) and acquired (somatic) genomic alterations in the samples have been catalogued.

Environmental Biotechnology

Environmental biotechnology research and development programme are focused on the development and use of biotechnological tools for management of environment and biodiversity conservation. The main focus was given on development of mitigation technologies for Climate Change, microbial technologies for environmental improvement, treatment process of industrial effluent, bioremediation of xenobiotic compounds, biodiversity conservation and characterization of biodiversity. Efforts were made for the treatment of wastes and abatement of pollution through bioremediation. Studies on microbial diversity of various environments and their genetic information were carried out for isolating micro-

organisms that could be used in the manufacture of enzymes and a wide range of bioactive compounds, as well as in bioremediation processes. DBT has taken up several initiatives and continued its support in various ongoing projects.

Bioremediation/Biodegradation

In a project implemented by TERI, New Delhi a pilot scale facility of bioreactor with working volume of 1000 liter has been established at Gualpahari with an up scaling facility for bulk production of Oil-zapper. Total 600 tonnes of oil zapper was supplied to oil companies. Bioremediation of oil contaminated soil in operation area of ONGC, IOCL, BPCL and HPCL is completed and the sites have been restored after bioremediation.

At IGIB and CPPRI, Saharanpur, technology for improvement of a process of biological reduction of AOX, colour, COD and BOD of waste water emanated from large pulp & paper industries was developed. The microbial consortium could bring down the colour upto 82% and lignin upto 76% besides reducing COD and BOD within the permissible limits.

At IIT, Delhi study undertaken on immobilization of heavy metals bioaccumulating microbial strains for

mercury bioremediation demonstrated the feasibility of manganese bioremediation and simultaneous manganese oxide nanoparticle synthesis by *Bacillus* sp. cells. The synthesized nanoparticles were characterized as orthorhombic MnO_2 with average size of 4.62 ± 0.14 nm. Manganese oxide nanoparticles could also be synthesized *ex-situ* by the cell lysate.

Delhi University conducted a study on isolation of bacteria capable of degrading endosulfan from soil using selective enrichment technique. *Achromobacter xylosoxidans* strain C8B was able to degrade endosulfan sulfate, which is highly persistent and toxic metabolite of Endosulfan.

At Bharthidasan University, Thiruchirapalli work on identification and evaluation of novel microbes in CETP of Tannery industrial units through molecular approach was carried out. Bacterial diversity in the effluent were analyzed through 16S rRNA amplification and sequence results revealed the dominance of firmicutes and the dominant genus is *Bacillus*, with variable species diversity. Notably, putative *Bacillus* sp, *B. firmus* and *B. licheniformis* were observed in all stages of treatment. These species might have the capability to degrade the complex tannin into simpler sub derivatives. Metagenomic DNA isolated from effluent and 16S rRNA gene was

amplified. Future course of action is to prepare 16S library of non-culture microbes and screen the novel tannase gene from the micro biome CETP.

At SPU, Vallabh Vidyanagar and IICT, Hyderabad, studies were undertaken jointly on application of periodic discontinuous batch operation to enhance treatment efficiency of dye containing wastewater. Two distinct consortia optimized for their physico-chemical parameters revealed that at higher salt concentration also these consortia were able to degrade dye. Reactor operation was carried out using simulated textile effluent containing nine different dyes (monoazo, diazo and triazo) and reactor efficiency checked for various shock loadings found that consortium sustained up to 500 mg/l dye concentration at two days retention time. Biochemical and electrochemical analysis showed basic understanding on the functional role of aerobic microenvironment in dye removal.

At IIT, Delhi laccase mediated degradation of textile dyes and textile wastewater was investigated. The process was developed in an enzyme membrane reactor using both batch and continuous methods. Degradation pathways were established for three commonly used dyes. Mechanism of action of laccase on complex triarylmethane dyes was shown.

At IIT, Mumbai in a study on development of a structured model and experimental validation for the prediction of the kinetics of competitive metabolic networks in hydrocarbon degrading organisms, the substrate uptake pattern of the model organism *Pseudomonas putida* CSV86 was studied. This organism preferentially utilizes aromatics over glucose and co-metabolizes them with organic acids. The strains showed simultaneous utilization of organic acids and aromatic compounds. A cybernetic model to predict the growth and substrate uptake of *P.putida* CSV86 was developed.

Biodegradable Plastic/ Biopolymer

In a multicentric project implemented by Osmania University, Hyderabad, IIT, Kharagpur and NIIST, Trivandrum, studies on cost effective production of lactic acid for Polylactide (PLA) synthesis and biodegradation was carried out. A total of fifteen agricultural and industrial wastes are screened for checking their potential to replace the refined sugars for cost effective production of lactic acid. Scaling up of lactic acid fermentation by *Lactobacillus amylophilus* GV6 with the optimized media composition was carried out. New bioreactor trial at IIT, Kharagpur showed promising results. Newly isolated indigenous cultures for PLA degradation were developed at NIIST, Trivandrum.

At ARI and NCL Pune, studies on development of blends and composites based on biodegradable polymer of microbial origin viz. PHA was carried out. The production of the biopolymer was optimized from using *Halomonas campisalis* strain in 14 L SS fermenter. PHA could be produced from cheap substrates like baggase extract and table sugar with significant reduction in cost of production. Scale up production of PHA carried out in 120 L SS fermenter with 85 L production medium resulted in 26 g PHA. The developed PHA was found to be biodegradable as per ASTM methods. The blends and nanocomposites of PHBV with nanoactive Al₂O₃, Optim, Nylon 11 and Hydroxyapatite were successfully prepared which show desired performance in terms of mechanical properties. The suitability of PHBV – Optim blend for the cellular growth has been studied.

Product from Waste

At IIT Delhi, biotechnological approaches for utilization of *Jatropha curcsa* oil cake and glycerol for obtaining value added products were explored. Two specific isoinhibitors for trypsin have been isolated and purified from deoiled *Jatropha curcas* meal. A new alcohol dehydrogenase from *Thermus thermophilus* (TTHADH) was isolated, purified and

characterized. TTHADH stereo specifically coverts glycerol into D-glyceraldehyde, a chiral molecule. Process optimization for producing monoglyceride from glycerol was carried out.

In another study on development of a bioprocess for the production of Polyhydroxy Butyrate (PHB) from bio-diesel industry generated glycerol, bacterial strains were screened for PHB production. Among these strains *Bacillus firmus* NII 0830 was found to be a good producer of PHB. Optimization of different process parameters were carried out to enhance the PHB production. The result showed that phosphate limited condition was more favorable for PHB accumulation by *Bacillus firmus*.

In a project on sustainable utilization of trash fish for the formulation of various valuable products, implemented by Annamalai University, TN, investigations lead to the production of Fish oil, Chitin and Chitosan, Fish Protein Concentrate (FPC), Fish Meal, Fish Pellet feed, Fish Bone Powder (calcium powder), Fish Collagen form various low value as well as trash/bycatch fishes. The products developed out of this project were periodically for its proximate composition, microbial status, shelf life etc.

Environmental Metagenomics

At MKU, Madurai, microbial diversity on goat skin surface was assessed by 16S rRNA gene amplification and sequence comparison. Unique sequences that shared sequences similarity with unculturable bacteria were submitted to the public database. A metagenomic DNA library with 70,000 recombinant clones were constructed and screened for clones exhibiting proteases activity. A novel alkaline serine protease with optimal activity at pH 10.5 was identified, purified and characterized. By PCR based screening two antibacterial protein coding genes *tmp1* and *tmp3* were identified. The inhibitory spectrum of Tmp1 was enhanced by random mutagenesis and site-directed mutagenesis. The site of action and 3D structure of Tmp3 were confirmed by fluorescent microscopy, CD and NMR spectroscopy. Identified alkaline protease could be considered for its applicability in detergent industries. Synthetic derivatives of Tmp1 and Tmp3 could be considered for therapeutic applications.

At IARI, New Delhi studies undertaken to assess the genetic and biochemical potential of soil microorganisms by culture-independent methods, a 781-member fosmid library in *Escherichia coli* with DNA extracted directly from soil has been constructed.

These clones have been checked for antibiotic production against different pathogens such as *Vibrio cholera* and *X. oryzae*.

At UDSC, New Delhi a protocol was developed for maximizing the extraction of DNA from the environmental samples that allows the extraction of humic acid free DNA in one-step. Metagenomic libraries have been constructed and the clones have been screened for xylanolytic activity. The xylanase gene was expressed and the enzyme was purified. Enzyme variants have been generated by site-directed mutagenesis and directed evolution, and these are being analyzed.

At BHU, Varanasi, work on bio-prospecting of novel genes from the metagenome of coal beds for the biotransformation of lignite coal into high efficiency fuels is being carried out. Coal bed metagenome was analyzed by extracting metagenomic DNA from the water samples collected from 800m depth of Jharia coal mines. The bacterial community was dominated by the members of *Azonexus*, *Azospira*, *Dechloromonas* and *Thiobacillus*. A plasmid and a fosmid library was also prepared from the coalbed metagenome. Nucleotide sequence of some of the plasmids/fosmids was determined and some potentially useful genes were identified.

At IIT, Mumbai, search was made for novel pathways, enzymes or operons involved in the degradation of aromatic compounds using metagenomic approach, the gene for terephthalate dioxygenase oxygenase component was amplified from *Pseudomonas aeruginosa* strain PP4 and *Pseudomonas sp.* strain PPD. The gene was used as a probe for screening the metagenomic library. The gene encoding the enzyme like salicylate 5-hydroxylase and conserved cupin-2 region of gentisate 1,2-dioxygenase were amplified from the naphthalene degrading strain in the library.

At NIIST, Trivandrum, work on construction and screening of environmental DNA libraries for novel beta- lactamase inhibitors and lipases was carried out. Soil metagenomic library undertaken from Western Ghats of Kerala was screened for lipase, protease, amylase and b-lactamase inhibitors. Eighteen clones positive for lipase, eleven clones positive for amylase and thirteen clones positive for protease were obtained. Partial purification and characterization of amylase and lipase were carried out. Esterase form clones were temperature stable (80°C), solvent tolerant (up to 25% methanol) and halo tolerant (up to 2M NaCl) and these properties make them very unique and highly desirable for industrial application including trans esterification reactions for biodiesel production and in organic synthesis.

At NEERI, Nagpur, mining the metagenome of activated biomass for new antibiotic molecules, culture based screening for antibiotics yielded two isolates that show antimicrobial properties against, *E.coli*, *Salmonella*, *Bacillus* and multi-drug resistant *Enterobacter*. The isolates have been identified by 16S rDNA sequence analysis as *Alcaligenes sp.* and *Pandorea sp.* The antimicrobial agent has been identified as Phenol 2,6-bis(1,1 dimethylethyl). Screening the metagenome has yielded one clone demonstrating antimicrobial activity against *Serratia*. Sequence homology demonstrates similarity to Lasso peptide and Polyketide Synthase I, both reported antimicrobial agents.

Biodiversity Conservation Studies

Animal Biodiversity

At CCMB, Hyderabad work on estimation studies of wild tigers in tiger reserves in India by DNA profiling of faecal samples has been carried out. The protocols for scat sample collections were established to obtain maximum DNA, to minimize losses during preservation and to quantifying and grade DNA extracts. Ten tetranucleotide and four dinucleotide microsatellite markers for genotyping individual tigers have been selected and screened. Protocols for two-step PCR and genotyping have been

standardized to get accurate results with minimal amounts of DNA and to ascertain the impact of habitat fragmentation, hostile landscapes with human presence on tiger presence and their movements.

At MKU, Madurai, molecular systematics and population genetics studies of lesser dog faced fruit bat *Cynopterus brachyotis* have been carried out. Studies show that morphological keys are insufficient to identify individuals of both species at high altitudes and areas of cohabitation. Many morphovariants may be taxonomically unique. Hill population of *C. sphinx* in Southern India was isolated and the occurrence of *C. sphinx* in high altitudes above 1000m was also reported.

Microbial Biodiversity

At ARI, Pune archaeal biodiversity from Indian Archipelago have been studied using molecular phylogenetic approach to document the microbial diversity (bacterial and archaeal) associated with mud volcanoes of Andaman Islands. These mud volcanoes erupted recently after the earthquake leading to Tsunami disaster of 2004. The data reported describes the account of the microbial diversity of the mud volcano evaluated by culture independent technique. This investigation based on 16S rRNA gene sequence analysis revealed the

presence of several novel species of bacteria and archaea.

Plant Biodiversity

At Annamalai University, TN conservation and genetic variations of three RET mangrove species (*xylocarpus mekongensis*, *xylocarpus granatum* and *excoecaria agallocha*) of Pichavaram mangroves, Tamil Nadu were studied. Micropropagation protocol was standardized for *Excoecaria agallocha* and standardization is under progress with *Xylocarpus* species. The plants propagated through seeds, vegetative and micropropagation have been hardened and reintroduced in the natural mangrove forest and in the degraded area where afforestation is continuing in Pichavaram. The establishments of the seedlings are around 82% with *Excoecaria agallocha*, 72% with *X. granatum* and 40% with *X. moluccensis*.

At Goa University, Goa studies on taxonomy, populations, environment, ecology, propagation, introduction and genetic diversity of *Phyllanthus talbotii* and *Pseudoglochidion anamalayana* have been carried out. ITS sequence shows that the genus *Pseudoglochidion* can be subsumed under the genus *Phyllanthus*; *Phyllanthus talbotii* is related to *Phyllanthus cinereus* of Sri Lanka. Five new populations of *P. talbotii* in Karnataka and Goa have been located

and their numbers estimated. Similarly populations of *Pseudoglochidion* in six sites have been estimated. Embryo culture of *Pseudoglochidion* is showing positive results for mass propagation. *Phyllanthus talbotii* has been reintroduced in existing populations and new localities.

Species Recovery Programme

At Shivaji University, Kolhapur in a study on recovery of RET species of *Ceropegia* from Western Ghats, micropropagation protocols have been standardized for *Ceropegia spiralis*, *Ceropegia attenuate*, *Ceropegia evansii* and *Ceropegia mohanramii*. In another programme at Shivaji University and ATREE, microsatellite markers have been developed for *Ceropegia fantastica* and using these markers the genetic variability of the populations has been assessed. Similarly in *Hubbardia heptaneuron* the genetic variability across the populations have been assessed using the microsatellites of *Oryza sativa*.

In the species recovery programme at NEHU, Shillong, *in vitro* mass propagation using seeds or suitable explants have been accomplished for recovery of *Nepenthes khasiana*, *Mantisia spathulata* and *Nymphaea tetragona*. Hundred percent of the 1000 plants of *N. Khasiana* were transferred to the natural habitat survived. Around 2000-3000 plants have been supplied to the Forest

Department and other agencies for re-introduction in the natural habitats.

CO₂ Sequestration

In a multicentric project implemented at NEERI, BHU, UDSC and RDU, Jabalpur on microbial sequestration of carbon dioxide investigators isolated the enzyme carbonic anhydrase that is responsible for carbon sequestration. Bacterial genes were cloned from some of these microorganisms introduced in to a suitable host. While inside bacteria, this enzyme was used for providing bicarbonates in many carboxylation reactions for bacterial metabolism. However, when isolated, the same enzyme can produce bicarbonates that can be precipitated as carbonates of Calcium, Barium and Strontium when mixed with solutions of CaCl₂, BaCl₂ or SrCl₂. Under certain conditions, recombinant carbonic anhydrase can also be used for producing 'nano-size carbonates'. The carbonic anhydrase produced from bacteria can not only be used for transforming CO₂ into inorganic mineral carbonates but they can also be used in value addition by producing nano-size carbonates for various biomedical applications.

At University of Hyderabad work undertaken to study the key responses of photosynthetic enzymes consorted with

overall plant growth performance in a fast growing tree species, *Gmelina arborea* Roxb (*Verbenaceae*). *Gmelina* plants were grown under ambient and CO₂-enriched conditions showed positive linear correlation with photosynthetic rates and RUBPcase activity with significant response to CO₂ enrichment. Periodic increase in biomass revealed that fast growing tree species like *Gmelina* exhibiting CA - mediated photosynthetic up-regulation can be used as potential tree species for carbon sequestration under predicted future climate change scenario.

At GBPUAT, Pant Nagar, a project on identification of oxalogenic tree and oxalotrophic bacteria for long term carbon sequestration was implemented. Number of trees have been identified showing the phenomenon of carbon accumulation in the form of inorganic carbon (CaCO₃). Amongst all identified trees, *Terminalia alata* has shown the real potential in a short time.

Nanoscience and Nanotechnology

DBT has taken a lead in promoting Nanoscience and Nanotechnology programs in the areas including drug delivery vehicles, new therapeutics, diagnostics, tissue engineering, bio separation, nanotoxicology, agriculture and allied areas. The highlights of the important knowledge outcomes are as follows:

Protein Nano medicine targeted to aberrant cancer kinome was developed at Amrita Institute of Nanomedicine and Nano science. The invention is related to an endogenous protein nanomedicine for the treatment of drug resistant cancer. Although, molecularly targeted small molecule kinase inhibitors (SMI) are effective against many types of cancer, development of point mutations in the kinase domain leading to molecular drug resistance is a major challenge. An endogenous protein nano medicine was developed that can overcome the drug resistance by delivering multiple small molecule kinase inhibitors targeted to aberrant cancer kinome responsible for the resistance. In this protein nanomedicine is also conjugated with cell-surface receptors that are over expressed in resistant phenotype. For refractory chronic myeloid leukemia, a nano medicine based on human serum albumin loaded with STATS inhibitor, sorafenib was developed and surface conjugated with transferrin ligands for targeted delivery. This receptor plus kinase (dual) targeted' transferrin conjugated albumin bound sorafenib' (Tf- nAlb-Soraf)' nanomedicine displayed uniform spherical morphology and drug encapsulation efficiency of 74%. The enhanced anti-leukemic activity of this formulation was found maximum in the most drug resistant patient samples that expressed highest level of TfR and STATS. Thus it was revealed

that by molecular diagnosis of patients, novel nanomedicine formulations can be custom designed and developed using this novel platform of protein nanoparticles.

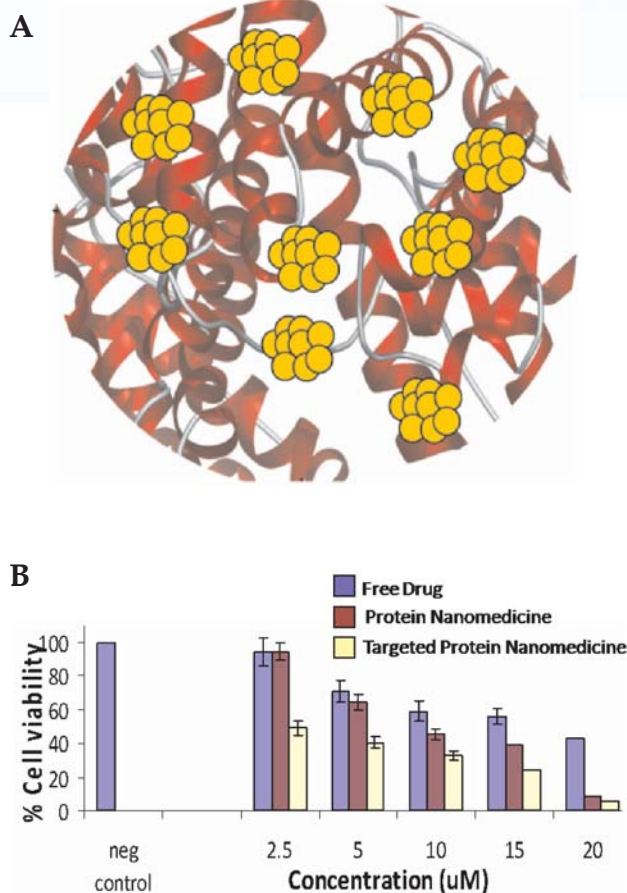


Fig. 4.25: A. Design of protein Nano medicine
B. Toxicity against drug resistant leukemia

In a project undertaken at Amrita Institute of Nanomedicine and Nano science, multimodal contrast agent based on bio-mineral nanoparticles was developed. A novel biomineral, hydroxyapatite, based nano-contrast agent developed showing image enhancement for five different

medical imaging modalities such as nuclear, magnetic resonance, X-ray-CT and near infrared (NIR) fluorescence, and Raman imaging, together with targeted drug or gene delivery properties. Specifically, the particle is based on nanoparticles of calcium phosphate (nCP) and calcium hydroxyapatite (nHAp), doped and/or conjugated with more than one impurity ion / molecule. The multifunctional nano-composite particle enable combined molecular imaging using single photon emission computed tomography (SPECT), raman imaging, MRI, CT and/or optical near-infrared fluorescent imaging. Another aspect of this invention relates to a method of making nanomedicine formulations based on the said nCP and nHAp particles, capable of delivering chemodrugs, small molecule inhibitors or nucleic acid drugs such as DNA, RNA, small interfering RNA (siRNA), micro RNA (miRNA) specifically to a targeted disease such as cancer.

An intrinsically fluorescent carbon nanospheres and a Process thereof was developed at Jawaharlal Nehru Center for Advanced Scientific Research, Bangalore. This invention provides solution of the problem involved in delivery of active molecules to nucleus, more particularly, intrinsically fluorescent and inherently surface functionalized carbon nanospheres

which are non-toxic. Also, these carbon nanospheres (CSP) were absorbed with CTPB [CSP-CTPB] and the absorbed CSP-CTPB are permeable to cells with nuclear targeting ability. The present invention also provides a composition, a process to prepare the composition comprising CSP with adsorbed active/ therapeutic molecules and a method for delivering active molecules in the brain. CSP-CTPB (HAT activator), could induce histone acetylation in the mice brain, which could have a great potential to design therapeutics for neurodegenerative diseases.

Institute of Chemical Technology, Mumbai, Targeted Nano particulate Drug Delivery System of Doxorubicin was developed for Hepatic Cancer Using Asialoglycoprotein Receptor Mediated Approach. Functionalized Nano particulate drug delivery system (NPDDS) was developed using a novel biodegradable polymer synthesized from sebacic acid using a receptor mediated targeting agent, for treatment of hepatic cancer. Accelerated stability study of PES-DOX NPs was performed according to ICH guideline and DOX NPs were found to be stable at the end of 3 months at all the test conditions indicating shelf life of 1 year. Biodistribution studies (in rats) revealed comparable liver concentrations of DOX solution, PES-DOX

NPs and PES-DOX-TAR. Lower heart concentrations with PES-DOX-TAR and PES-DOX NPs suggested the possibility of lower cardiotoxicity,

In continuation of the ongoing efforts, various multifunctional nanoparticles were developed and different parameters were optimized at IIT Kharagpur for various medical applications. Some of them are (i), Phosphonate-Grafted, Ultra small/ Iron Oxide Nanoparticles for Combined Targeted Cancer, (ii) Highly biocompatible and water-dispersible, amine functionalized magnetite nanoparticles, prepared by a low temperature, air-assisted polyol process, (iii) A straightforward designed Magnetic nanoparticles loaded with doxorubicin for targeted delivery and MRI contrast agent, (iv) Hydrophobically modified superparamagnetic nanoparticles for paclitaxel delivery, (vi) Synthesis, characterization and in vitro biological evaluation of highly stable diversely functionalized superparamagnetic iron oxide nanoparticles: (vii) Folate receptor targeted, carboxymethyl chitosan functionalized iron oxide nanoparticles, (viii) Synthesis and characterization of highly stabilized manganese ferrite nanoparticles, (viii) Magnetite nanoparticles using an aminophosphonic acid coupling agent, new, ultradispersed, iron- oxide folate nanoconjugates for cancer-specific targeting, (ix) A novel detection of total count of

Staphylococcus aureus using anti-toxin antibody labeled gold magnetite nanocomposite by fluorescence microscopy for Staphylococcus aureus (x) Single step surface modification of highly stable magnetic nanoparticles for purification of His-tag proteins, (xi) Design of magnetic Nickel nanoparticles for purification of His- Tagged protein (xii) Magnetic nanoparticles as Supports for Enzyme immobilization and encapsulation

At Amrita Institute of Nanoscience and Nano medicine, novel type of stimuli responsive graft co-polymeric nanoparticle based on polymers like chitosan and fibrinogen were successfully synthesized as a promising smart material for the controlled cancer drug delivery applications. The preliminary work on radiofrequency was conducted by incorporating 5 nm sized Au-NPs in to chitosan as well as fibrinogen based thermo sensitive polymeric nanomaterial. Due to the presence of PNVCL/PNIPAAm, they showed a temperature-induced phase transition and tunable LCST at 32-45°C in aqueous solutions. The drug release was high at above the LCST of carriers in all cases compared to that at below LCST, suggesting that these materials could be useful for the RF based cancer therapy. The *in vivo* Kodak imaging studies on Swiss albino mice showed that these particles

could clear via intestinal route of elimination.

At Indian Institute of Chemical Technology, Hyderabad, nanomaterials were designed and synthesized with fluorophores for simultaneous use of tracking and delivery. Thiol was modified as well as guanidine coupled to a single nano-tube. This allows the development of cleavable functionalization for a wide range of biological cargoes including nucleic acids (DNA, RNA) and proteins. Many genes that are responsible for the aggressive metastatic behavior of the cancerous cells such as Bcl2 and cyclin D1 have been efficiently silenced during the nano delivery and cellular uptake studies. The serum stability studies have proven the novel role of these nanotubes and their stability for effective drug targeting. The binding of the nanotubes with nucleic acids such as DNA was found to be highly efficient at the optimal concentrations. This provides future hope for the cancer drug delivery as it has the advantage of serum stability, binding to nucleic acids, thiol bond cleavage and the organic nature having biodegradability.

At Institute of Minerals and Materials Technology, Bhuvneshwar NanoZnO film was used to develop smart packaging materials. The Nano film could be

deposited on borosilicate glass and thin Al foil by spray pyrolysis and radio frequency plasma technique. The important feature of the ZnO film deposition in this investigation includes a novel concept where zinc acetate was used in the form of a solid pellet which underwent sublimation at 245°C inside the plasma reactor to produce zinc acetate vapor (precursor) that was allowed to react in situ with the oxygen plasma (produced by radio frequency in the reactor chamber) resulting in the formation of ZnO and its film deposition on glass and Al foil. Such films could be used for food packaging purpose to increase the shelf life of food items as the films coated on the Al foil showed good antibacterial properties toward *E. coli* and *P.aeruginosa* even in dark. It was also established that ZnO film of more than 500 nm thickness is fit for reuse as food packaging material without compromising the antibacterial activity. Diffusion of Zn²⁺ ions into the bacterial cell is attributed to be one of the possible mechanisms for the observed antibacterial activity in the Nano ZnO thin film.

Nanotoxicology research is being continued at Amrita Center for Nano Science and Molecular Medicine to understand various physicochemical parameters associated with toxicity of different nanomaterial. Strong base for nanotoxicology research facilities

are being expended at this center to study various toxicological aspects of nanomaterial. The facilities would cater to the needs of the investigators from the institutions other than this center

RNAi Technology Platform

RNAi approaches are extensively used as tool in understanding various gene silencing mechanisms. RNAi approach was used in management of diseases of important crop, conferring attributes to the plant to combat other biotic and abiotic stresses. It has used as proven excellent tool in the area of therapeutics and new medicine in antimalarial therapeutics, as tool for prognosis and diagnosis of for various cancers using their classic signature.

At ICgeb, New Delhi, studies were carried out on profiling and mining the sncRNAs from Indian rice varieties tolerant to salinity so as to tap the natural variation existent in different Indian rice cultivars with reference to expression state of the small RNAs and/or their specific targets to generate fundamental knowledge of plant responses to salt/drought stress applications in crop improvement. This has resulted in the identification of 210, 169 and 172 known miRNAs from three main tissues viz. leaf, root and flower of local basmati variety; with 27, 10 and 8 miRNAs being uniquely

represented in the respective tissues. On comparing the digital data of known rice miRNAs obtained from leaves of salt-stressed basmati seedlings and the unstressed seedlings of a salt-tolerant variety, Pokkali around 5 salt-specific miRNAs were identified. Further a tool for the prediction of mirtrons (a novel class of miRNAs) have been developed and used for predicting mirtrons in rice. Analysis of 70 introns for minimum number of mismatches in the probable miRNA regions of the mirtrons and best hairpin structures, exhibited 16 most probable intronic miRNAs of which 3 hairpin structures showed the lowest free energies.

Studies carried out at Delhi University on Viral Suppressors namely genomic, synergism and silencing. These three suppressors viz. PRSV-HcPro, CMV-2b and ToLCV-AC4 were cloned, expressed and

characterized for their role in micro RNA binding. RNAi based silencing constructs were developed to silence the viral suppressors and their efficacy of silencing was tested under *in vivo* conditions. Basic mechanism by which these viral suppressors are regulating RNAi mechanism was explored. PRSV-HcPro was found to regulate micro RNAs, directly by binding to them in double stranded form and this binding is temperature dependent. CMV-2b, showed differential binding with ds-miRNAs. ToLCV-AC4 does not bind directly with the micro RNAs but constitutive expression of AC4 in tomato alters host physiology. It was inferred that PRSV-HcPro and CMV-2b are involved directly in binding with micro RNAs, but behaves differently

MYC2 is a very well established transcription factor in Arabidopsis that

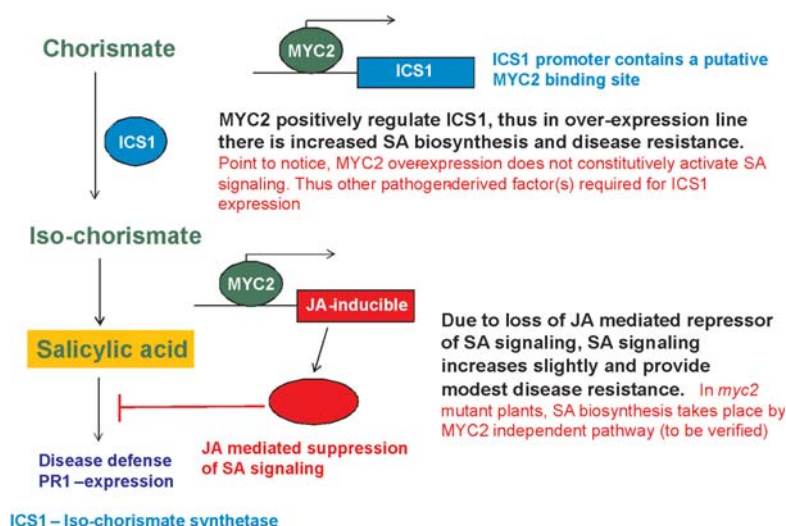


Fig 4.26: The possible mechanisms defense regulation

receives signals derived from jasmonic acid (JA) and activates expression of JA inducible genes. Studies were carried out to uncover MYC2 homologue from the crop plant rice at JNU, New Delhi. RNAi lines for two putative rice homologues of MYC2 were generated through agrobacterium mediated gene transfer technology in TP309 variety of rice and functional homologue of Arabidopsis MYC2 gene from rice (OsMYC2) were identified. A novel role of MYC2 was uncovered in activation of salicylic acid (SA) mediated plant defense against bacterial pathogens.

The role of miRNA alterations in the pathophysiology of Type 2 diabetes was studied at Madras Diabetes Research Foundation, Chennai. Through this study it was found that miRNAs contribute to the disease mechanism(s) underlying insulin resistance and type 2 diabetes and novel drug targets were identified. Microarray study revealed that muscle-specific miRNAs (**myomiRs**); miR-1, miR-133a, miR-133b and miR-206 were down regulated in skeletal muscle not only from Type 2 diabetes patients but also in prediabetic subjects. Down regulation of myomiRs was also demonstrated in high-fat diet-induced insulin resistant rats. A sub-study also revealed impairment of an immunomiR viz., miR-146a which links subclinical

inflammation, insulin resistance and poor glycemic control in patients with Type 2 diabetes.

Role of microRNAs in HIV neuropathogenesis was studied at CCMB, Hyderabad. Expression of functional HIV-1 recombinant Tat protein from HIV-1 clade B and clade C was studied and microRNA array data were generated through miRNA array. Expression of selected microRNAs was validated through real time PCR and targets were predicted of differentially expressed selected miRNAs using bioinformatics prediction tools. The target gene was found, whose regulation is mediated through microRNA expression pattern in the human brain microvascular cells exposed to HIV-1 Tat C protein.

Studies were carried out at NCCS, Pune on silencing osteopontin and its downstream oncogenic molecules as suppressor of the tumor growth and angiogenesis in breast cancer. It was found that MDA-MB-231 cells transfected with OPN siRNA (SiGENOME SMART Pool) showed significant reduction of Cox-2 and VEGF expression. Moreover, MDA-MB-231 cells transfected with OPNi along with Cox-2i and VEGFi inhibit the cell migration. These results suggested that silencing OPN and/or Cox-2 and VEGF attenuates the cell migration and tumor growth in breast cancer models.

At Dr. B R Ambedkar Centre for Biomedical Research University of Delhi studies were undertaken on Deciphering Dendritic cell function during *Mycobacterium tuberculosis* infection by RNA. Studies resulted in identification of genes that play a significant role in modulating immune responses to *M. tb* from DCs. Genes such as USP25, SNRK and SENP8 displayed broad negative regulation with respect to pro-inflammatory responses from DCs as well as regulation of *M. tb* survival. Further, many of the genes identified acted in a specific manner that are indicative of fine tuning of immune responses during infection and the ability of *M. tb* to modulate the activation status of these genes for immune evasion. This indicated that these genes played a negative role during specific antigenic stimulation as well as whole bacterial infection. Therefore, delineating the mechanisms employed by these genes in regulating some of these responses could increase understanding on the roles played by these genes in the pathogenesis of *M. tb*.

At CCMB, Hyderabad, a microRNA database for leukemia was created which showed an extensive network between microRNAs and their respective targets. These were further confirmed by creating a microRNA profile of different leukemia types, T-ALL and B-ALL. The microRNA and protein expression profile revealed a

complicated network interaction between them using Gene Go. The microRNAs specifically and significantly expressed in a particular type of leukemia and not in other class were further selected for patenting.

At IIT Madras, work was carried out to Design and Synthesize Peptide Mini-Vectors for Receptor Mediated Delivery of siRNAs. Novel peptide sequences were identified which do not exert any negative influence on the ability of siRNAs in mediating RNAi effect and a method was developed to synthesize enantiomerically pure 2,3-dihydroquinazolinones. A conjugate strategy was also established by both C & N-terminus of peptides can be kept free of conjugating sites to enable the interaction with receptors.

Effective siRNAs against HIV-1 Tat and Vif/Vpr were designed at NII, New Delhi. Rz-siRNA constructs showed more potent HIV-1 activity. Intracellular processing suggested that siRNAs were processed correctly. It was also established that bi-specific or multi-specific approach is significantly better than any single antiviral approach. Effective inhibition of HIV-1 gene expression and replication could be achieved. Most of the constructs worked against subtype C genes which is an important achievements considering >90% infections in India is considered to be driven by HIV-1 genetic subtype C.

Energy Bioscience Programme

The Department has been supporting programme on Biofuels and Bioenergy with a focus on second generation biofuel using lignocellulosic ethanol and algal biofuel. Efforts were continued for feedstock development, biomass production and optimization of production technologies for scale-up to make them commercially viable. The DBT-ICT (Institute of Chemical Technology) Centre for Energy Biosciences (CEB) has been established at Mumbai with the primary focus on developing biotechnologies for deriving energy from renewable resources. The DBT-IOCL Centre for Advanced Bioenergy has been established at R&D IOCL Faridabad.

Salient achievements of the New Initiatives taken and ongoing programs during the year are briefed below.

Energy Bioscience Centres

DBT-ICT Centre for Energy Biosciences

The DBT-ICT (Institute of Chemical Technology) Centre for Energy Biosciences (CEB) is developing technologies for deriving energy from renewable resources. An emphasis was given on improved bio-ethanol production from any given biomass,

developing a bio-refinery approach for selected biomass and other biofuel technologies such as bio-diesel, bio-hydrogen and bio-methane. Highlights of its achievements are:

- **Cellulosic Ethanol**

The Centre has developed an economically viable and scalable technology for cellulosic ethanol from all types of agricultural residues and energy crops. These features include biomass fractionation and enzymatic saccharification to fermentable mono-sugars and lignin followed by conversion of both C6 and C5 sugars to ethanol. The ICT Technology for Cellulosic Ethanol, used to design a 10 ton biomass/day processing plant to convert rice/wheat straw ; bagasse, and many other varieties of biomass into sugars and lignin, and onto ethanol for use as fuel or chemical intermediate. The designed pilot plant has been erected at the India Glycols Ltd. site at Kashipur, Uttarakhand with support from BIPP, BIRAP, scheme of the department of biotechnology.

- **Algal Biotechnology**

A state-of-the-art laboratory for algal biotechnology has been set up with basic

infrastructure coupled with 1000L and 5000L raceway ponds with novel designs as well as set of 10L controlled photobioreactors, all equipped with microprocessor based SCADA controlled systems. R&D capability in the areas of *Agrobacterium* mediated nuclear transformation has been developed with selected algal strains.

- **Fermentation Technology**

Under fermentation technology, high cell density and immobilized cultures were implemented for tenfold higher rates of fermentation of sugars to alcohols and acids, without impairing product yields. Metabolic flux analysis coupled with metabolic engineering has been applied to several fermentation systems aimed at production of primary as well as secondary metabolites systems exhibiting multiple steady states and hysteresis have been modeled in collaboration with School of Chemical Engineering, Purdue University, USA.

- **Enzyme Technology**

Novel two step rapid process has been developed and patented worldwide for enzymatic saccharification of cellulose and hemicellulose. Mathematical

model describing the underlying phenomena and affording design of the enzyme reactor system has been developed and implemented on industrial scale with provision for re-use of the cellulolytic enzymes over many cycles.

- **Synthetic, Molecular Biology and Protein Engineering**

Notable successes of the programme are thermostable β -xylosidase from *Geobacillus thermodenitrificans*, over-expressed in *Escherichia coli*; endo-cellulase and α -glucosidase with lower substrate inhibition and fusion proteins designed and expressed in *E. coli* in collaboration with ICGEB, New Delhi; and design and expression of a non-specific lipase expressed in *Y. lipolytica*.

DBT-IOCL Centre

DBT is setting up the DBT-IOC Advanced Bioenergy Research Centre. This centre is coming up at Indian Oil's R&D complex at Faridabad as a partnership centre of DBT and IOC. An MoA was signed on 11th August 2011 with Indian Oil Corporation, the largest Public Sector enterprise in the country with MD of Indian Oil Corporation. The centre aims at the following major objectives:

- To conduct a multi-disciplinary bioenergy research involving biology, chemical and material sciences etc.
- To provide a platform for integrating dis-jointed research activities pursued in several areas related to biofuels by various institutes.
- Development of “institutional capability” to address the bioenergy need of nation based on “science - enterprise model”.
- Provide National capability of pilot level scale-up of developed technologies.

Bioenergy Center for Research in Synthetic Biology is being set up at ICGEB New Delhi considering ICGEB's strength in Synthetic Biology Research.

Biodiesel

Feedstock improvement and Multilocational Trials

The thrust of the programme was on Biodiesel-feedstock development and improvement of *Jatropha* under the micro mission on production and demonstration of quality planting material. The department of biotechnology has initiated systematic programs on germplasm collection,

evaluation and accessioning to identify superior material from existing natural variations. This germplasm improvement programme was launched to enhance the productivity and yield.

A total of 13 institutions are working on various aspects from survey of superior material to experimental plantation and 500 accessions were found promising on the basis of percentage oil and tolerance to local conditions which were used for raising plants.

Operational guidelines have been framed for the Micromission on production and demonstration of quality planting material of *Jatropha*, in consultation with scientists and experts in the field defining criteria for selection of quality material. Multilocation trials of 20 promising accessions was initiated in 2007 to study the effect of set agronomy practices, soil and agro-climatic conditions on performance of accessions at with 9 partner institutes.

In addition to agronomy trials, 100 accessions are also being tested for silvicultural trial along with agro climatic performances.

These accessions have been further bulked up under controlled nursery conditions. DBT Network has resource of 500 selected

accessions for future improvement, multiplication and bulking. This resource base is being conserved at five centres (Tamil Nadu, Odissa, Haryana, Assam and Gujarat) in the country.

Conservation and resource maintenance of selected *Jatropha* germplasm

Jatropha germplasm resource centres have been established at 5 different states and institutions for Conservation of 500 accessions of *Jatropha curcas* and as clonal and seedling material for multiplication and bulking.

Germplasm banks of *J. curcas* were established at Kudankulam and Jeypore during the year. The project aims at standardization of the cultural practices and systematic documentation of the agronomic characters of the accessions.

R&D in *Jatropha*

A Network Project on Gene Prospecting in *Jatropha* for High Seed Oil Content

Within the *Jatropha* R&D Network six centers i.e. Jayee University Solan, IAR Gandhinagar, VMSRF Bangalore, SRM Unjversity Chennai, NBRI Lucknow, MSSRF Chennai were involved. The overall goal of different R&D projects has been to understand molecular biology of fatty acids

biosynthesis and oil content in *Jatropha* seeds through generation of ESTs, full length cloning of fatty acid biosynthesis genes and development of molecular markers (SSRs/ SNPs) either through ESTs or comparative genomics with castor bean. The following leads were obtained in the past 4 years:

- Total of 16,000 ESTS and 70,000 short transcripts have been generated from different developmental stages of *Jatropha* seeds.
- All genes involved in fatty acids biosynthesis, including seed oil accumulation have been cloned to full length.
- Gene constructs for *Jatropha* seed oil increase have been developed for major genes. These genes have been functionally validated in Arabidopsis or Tobacco for increase in oil content.
- Increase in Arabidopsis seed oil content (~20%) has been observed through a *Jatropha* gene, JcDGAT under a seed specific promoter.
- Transformants of *Jatropha* have been developed with a multigene construct (LPAAT from coconut and FAT A from *Jatropha*) and their seed oil content analysis is being done.

- Large numbers of molecular markers (SSRs/SNPs) have been developed either from ESTs (EST-SSRs) or comparative genomics with castor bean (SSRs/SNPs).
- Whole genome sequence of *Jatropha* has been computationally analyzed for all SSRs.

Transesterification

The crude *Jatropha* oil has FFA about 5% which should be below 0.5% for further transesterification. Hence 50 kg batch experiments on esterification were successfully carried out at IICT Hyderabad to reduce the FFA to below 0.5%. Almost complete conversion of oil to esters could be achieved.

Lignocellulosic based Bio-ethanol

Department has been supporting various projects on cellulose Bioethanol which includes developing technology for pretreatment of substrates, enzyme development for breakdown of different substrates, lignocellulosic conversion from lab to pilot scale, process development and downstream process technology.

Pretreatment and Pelletization

Studies on pelletization and delignification

of cellulosic biomass (rice straw, cotton stalk, sweet sorghum, switchgrass, *Prosopis juliflora* and *Lantana camara*) were carried out at CIPHET Ludhiana where two stage pretreatments involving an alkali and an acid was tried for cotton stalks, *Lantana camara* and *Prosopis juliflora* which resulted in 85% or higher delignification for all the three residues. Enzymatic hydrolysis of the above treated substrates resulted in overall hydrolysis efficiency of 82% and 84% for cotton stalk and *Lantana camara*, respectively at 15% substrate loading.

Enzymatic hydrolysis and fermentation of lignocellulose

ICGEB is developing a technology for cost effective production of bioethanol from lignocellulosic biomass and has discovered novel α -endoglucanase (Endo5A), α -glucosidase (Gluc1C) and xylanase (Xyl11D) from a *Paenibacillus* sp (deposited at MTCC with accession no. 5639) isolated from the gut of an insect living on the cotton plant and cloned and expressed them in *E. coli*.

Efforts are continued for optimization of high-level extracellular expression of these enzymes in *E. coli* for effective hydrolysis of plant biomass condition. Higher expression level of pyruvate dehydrogenase operon (PDH) resulted in higher ethanol yield. Further deletion in the competing

pathways resulted in reduced production of lactate, succinate and acetate and higher ethanol yield. The strains SSY07 produced ethanol as major product and acetate and format as minor products from glucose and xylose whereas strain SSY10 produced ethanol as only product with higher yields from both the sugars.

A new yeast surface displaying vector was developed at Osmania University having TEF, a constitute promoter, genticin (antibiotic) cassette for selection and ARS sequence for maintaining high copy number in yeast. Pretreated rice straw was used for simultaneous saccharification and fermentation using this construct and in initial studies 80% hydrolysis and 95 % fermentation efficiency was obtained in 36 hours.

Process validation of Lignoceullulosic ethanol production

At UDSC New Delhi a pretreatment method, which fractionate ~100% hemicellulosic sugars and remove ~ 90% lignin from *Prosopis juliflora* and *Lantana camara* has been optimized. The ethanol production from both the lignocellulosic substrate i.e., *P. juliflora* and *L. camara* has been scaled up successfully to 20L and the mass balance studies of ethanol production from both the substrates have revealed 83-

86% carbohydrate recovery and 84-86% ethanol fermentation efficiency. The process has been validated at DBT-ICT Centre for Energy Biosciences, ICT Mumbai.

Bioethanol from Cassava Starch Flour Residue

A significant achievement of the work carried out at CTCRI Thiruvanthpuram is standardization and development of process technology for production of ethanol from CSFR, a solid waste discharged from cassava starch industries. Very high ethanol yield (390 l/tonne of dry CSFR) was obtained in the new technology, making CSFR an alternative substrate for ethanol production.

Biobutanol

Butanol is being looked upon as a sustainable and next generation biofuel. Studies are in progress for production, process optimization, scale up at UDSC New Delhi and ARI Pune. Process optimization for higher butanol production was carried out using one variable at a time and statistical approach (Plackett-Burman and Response Surface Methodology). An increased yield of 17.50 g/L of butanol (ABE-23.0 g/L) was achieved after fed batch studies. The production of butanol was successfully scaled up to 30 L fermenter under the optimized conditions (16.40 g/L)

(Photo 2).To purify butanol from the fermentation broth gas stripping was adopted with recovery of 50% followed by further purification by pervaporation with 40% recovery and 100% purity as confirmed by NMR analysis.



Fig. 4.27: Butanol production at 30 L Scale

Bio Hydrogen

Department has recently initiated supporting research projects on production of biohydrogen realizing the potential of biohydrogen as a fuel for future. TERI , New Delhi has taken a lead in this regard with support from DBT. New *Clostridium butyricum* strain TM 9A has been isolated, optimized and studied for biohydrogen production using different cost effective substrates and maximum hydrogen production was obtained at 2.5% molasses concentration. The process was also been scaled up at lab scale and results

demonstrated that *C. butyricum* TM 9A strain could produce 14 liter of pure hydrogen from 10 liter of basal nutrient solution.

Algal Biofuel

Algae, as a research material for biodiesel has been identified as a priority area of research. Studies have been initiated to collect, identify and characterize algal strains which will have more oil/lipid content. To have large amount of biomass, mass cultivation has been started using open pond system, (Raceway ponds), photo-bioreactor etc. Besides, growth conditions of selected species are being optimised for high oil yield. Under this algal network programme 12 national laboratories/ institutions/universities are involved from across the country.

Algae Collection and Repository

Conservation and characterization of Fresh water Cyanobacteria / microalgae at IBSD, Imphal, Manipur

Nine hundred thirteen (913) cyanobacterial isolates have been purified, morphologically characterized and preserved at Fresh water Repository set up at IBSD Imphal. These isolates belong to 32 genera collected from different ecological habitats of North East Region of India. Besides the cyanobacteria

a total 315 micro-algae also been collected from North East and Western Maharashtra.

Algae Collection and maintenance-Marine water (NFMC)

National Facility for Marine Cyanobacterial repository at Bharathidasan University has been upgraded to 527 marine cyanobacterial strains collected from the coastal areas of Tamil Nadu, Puducherry, Gujarat and Andaman island. The facility has been selected for the Arctic summer expedition for the microalgal survey. So far, 19 cryophilic cyanobacteria and 11 microalgae has been isolated from Arctic survey and maintained in the repository.

Almost 126 marine cyanobacterial strains have been supplied to 30 research institutions with in India for research purposes. In order to enrich the microalgal repository, coastal stretch from Thengapattinam to Ervadi was also covered under survey.

All the strains in the repository have been identified based on morphological means. Molecular confirmation with selected 3 molecular markers viz. 16SRNA, *ITS* and *cpc* regions is in progress. So far, 60 isolates of the collected samples have been screened for different parameters like oil content, fatty acid profiling, colour, odour, pH, specific gravity, refractive index, and density.



Fig. 4.28: NFMC Repository

Cultivation / Biomass Production Technology / Biomass Harvesting and Processing

Methods are being optimised to develop efficient oil extraction process from algal oil at pilot scale at Bharathidasan University. Selected strains have been optimized for mass cultivation (25 – 75 litres) under semi continuous mode. At present detail investigation on scaling up of cultivation of alga in continuous system at 250 liters is in progress optimization of downstream processing methodologies is being carried out.

At IIMT Bhuvaneshwar eight numbers of Raceway ponds, each having 100 sq mt surface area and 0.5 m depth with capacity of 40,000 liters each have been designed, constructed and put into operation. Raceway ponds have the provision for necessary carbon dioxide fluxing, control and instrumentation stations, paddle wheel for proper mixing, harvesting system using vibrating membrane filter, etc, motors and CO₂ sparging facility etc.

Biomass harvesting was a challenging issue due to very small cell size and their slow rate of colony formation. Hence poly-electrolytes like sodium alginate and chitosan were used out of which sodium alginate was found to be effective in

aggregating the algal cells together enabling easy harvesting. Harvested biomass was dried and lipid extraction was carried out with benzyl alcohol.

Algae Production using industrial effluents

Different industrial effluents like pharmaceutical wastewater, dairy wastewater, winery wastewater and sewage have been studied for lipid productivity by Green Micro Algae at TERI. Green microalgae were found to be efficient in removing nutrients and pollutants from industrial wastewaters and produce biomass and lipids for biodiesel preparation.

Biogas (Biomethanation)

Validation of exogenous enzyme application for enhancement of biomethanation process was studied at ARI Pune. The studies carried out to validate the effect of enzyme addition on anaerobic digestion of vegetable waste in batch experiments have shown that enzyme addition increased the methane yield in batch mode. It was observed that single cellulase, alone can be sufficient to show good increase (ca. 1.5 fold) in the methane yield as compared to dual enzyme addition. Enzyme can be added directly into the digester instead of any pretreatment.

Capacity Building

The Department has also instituted Energy Bioscience Overseas Fellowships for scientists of Indian origin who are working outside the country in the field of Energy Biosciences (including Biofuels, Bioenergy etc.). The main objective of the scheme is to support scientists of Indian origin who wish to return to the home country and pursue research of high calibre in the area of Energy Biosciences. The duration of the Fellowship

is for 5 years, which in exceptional cases, may be extended by another 5 years. Four candidates have been selected for this fellowship joined host institutes ICT Mumbai, and IISER Calcutta.

The Department has also initiated a scheme "National Energy Bioscience Chair" to have excellent team leaders in the Bioenergy area who can help in building innovative teams to address the major challenges in this sector.



BIOTECHNOLOGY PROGRAMMES FOR SOCIETAL DEVELOPMENT

The programme was continued for the socio-economic upliftment of SC/ST population. Training and demonstration programmes in various biotechnology based activities were undertaken on proven and field tested technologies related to animal husbandry, fish seed production and catfish culture, seed production, agro technology, vermicomposting, integrated farming interventions and organic cultivation of spices, medicinal and aromatic plants and mushroom cultivation etc. Various biotechnological activities undertaken could benefit SC/ST target population under the programme. Some highlights of the programme area are as follows:

Programme for SC/ST Population

Animal Husbandry

A Project was undertaken for the socio-economic upliftment of SC/ST farmers through animal husbandry. Beneficiaries trained on goat rearing, dairy farms, poultry farms, improved health care, clean milk production, value addition in milk & milk products. Training for adoption of scientific animal husbandry practices to improve the

production. Vaccination and treatment camps were organized with the help of State Govt. Livestock development officer and more than 3500 animals were treated for various diseases. Animal owners were provided medicine for deworming and mineral mixture during the animal health camps. Beneficiaries earned around Rs. 20,000/- annually through adoption of different animal husbandry practices.

In an another project on enhancement of income generation of SC/ST farmers was implemented in Kota district of Rajasthan. Improvement of animal health & their productivity through nutrient rich animal feed blocks were undertaken by Gramin Vigyan Kendra, Society for Environment & Development. Awareness programmes were organized 120 beneficiaries were provided intensive training on various aspects of animal health and productivity. SHG groups were formed and engaged in making the animal feed block under the brand name 'Pashu Amrit Battika' and marketing. Farmers feeding their animals realize increase in the milk production and increase in rate of survival among adult & kids.

Training & demonstration on Emu and Turkey rearing was implemented by Krishi Vigyan Kendra-Sylvan, for the economic upliftment of scheduled tribe families in Senapati district, Manipur. Twenty SHGs formed by identifying 200 tribal farmers including women beneficiaries belonging to BPL from two T.D. Blocks namely Saitu-Gamphazol and Kangpokpi. Eight training programmes conducted on Emu and Turkey rearing and provided knowledge on various technical and financial aspects and helped the beneficiaries in the establishment of infrastructure for setting up Emu and Turkey enterprises. A nucleus centre of Emu and Turkey were established to popularize, replication and supply of chicks to the interested farmers.

Another project on Socio-economic development of resource poor tribal families was implemented on piggery in



Fig. 5.1: Osmanabadi Buck in the Nondescript Goat Flock

Senapati district, Manipur. One hundred poor tribal beneficiaries from Kangpokpi T.D. Blocks including women, landless persons, and educated unemployed youths were selected and trained through SHG groups on advance management of crossed bred piglets. Beneficiaries were provided piglets (one male and one female), shade feed materials and medicines. Trained beneficiaries earned an average annual income of Rs. 28800.00 per year through piggery.

Fish Seed Production

Carp seed production for the livelihood of SC/ST communities in Nayagarh and Mayurbhanj districts of Odisha were operated by CIFA, Bhubaneswar. FRP carp hatchery units installed in various villages in these two districts for training on carp seed production, and also on establishment of mobile hatchery for fish seed rearing. Around 200 persons trained on different aspects of the freshwater aquaculture, carp hatchery operation, induced breeding, seed rearing and their management. The spawn produced from the hatcheries were stocked in nursery ponds for fry and fingerling production with higher survival rates in advanced fingerlings. Awareness programme undertaken by involving various stakeholders including hatchery operators. One of the beneficiaries from Nayagarh

District, Odisha, awarded with a scroll of honour on National Fish Farmer's Day observed at CIFA, Bhubaneswar.

Catfish Culture

Propagation and demonstration of native catfish culture for self employment of SC/ST farmers were taken up at St. Xavier's College, Tamilnadu. Commercially important catfishes viz; *Heteropneustes fossilis* (singhi), *Mystus gulio*, *Mystus montanus* and *Ompok bimaculatus* maintained at Aqua-farm and brooders of *H. fossilis*, *M.gulio*, *M.montanus*, *O. bimaculatus* were injected with hormones for spawning and larviculture. Training programmes were conducted at Palayamkottai, Pettai and Srivaikundam through which 200 SC/ST farmers trained on seed production, larval rearing and culture of native catfishes. Beneficiaries have undertaken plankton culture and succeeded in mass production

of Moina, Daphnia and Rotifers. Adoption of catfish culture technology by unemployed youths earned about Rs. 60,000/year.

Seed Production

Training programme was conducted on production of quality seeds of groundnut to meet the seed demand locally and also to increase the livelihood of the famers from Bijapur district of Karnataka. A series of lecture and interaction sessions were organized for 150 farmers of Kumathe village on various aspects of quality seed production of groundnut harvesting, processing, storage and maintenance of seed quality. Ten adopted beneficiaries were provided breeder seed of high yielding variety having resistance to late leaf spot and rust. Farmers were encouraged to take up commercial seed production programme under integrated crop management.



Fig. 5.2: Fish catch haul

Agro technology

A programme was undertaken for dissemination of need based technology for economically productive agricultural practices. Awareness and training programs was conducted on various aspects of soil and water testing, fertilizer application, green manuring, INM and IPM technologies. Commercial crops on cultivation of paddy,

blackgram, cashew, vegetables, Jowar; backyard kitchen gardening were introduced to the farmers with the integrations of animal husbandry practices. Upgraded breeds of cattle and poultry were introduced to the farmers and they were trained on advanced management practices which resulted an additional family income of Rs.10,000/-. Through adoption of integrated farming system drudgery in women were reduced to an extent of 50% with increased farm efficiency.

Vermicomposting

Training and demonstration activities vermicomposting and use of vermicompost on vegetable cultivation were undertaken for income generation of SC beneficiaries selected in consultation of local SHGs, Gram Panchayats. Vegetable seed for kharif and Rabi season distributed to 50 beneficiaries and supervised their demonstrations at field level. By adopting this simple and beneficial technique, beneficiaries realized increased production.

Dissemination of vermicompost production technology was taken up for farmers in Mysore district of Karnataka. The wastes generated from agriculture were used for vermicomposting. Beneficiaries from 15 villages were trained on various aspects of vermicomposting technology for the

economic and self-sustaining their livelihood. One hundred beneficiaries adopted vermicomposting for income generation.

In another project at Gulbarga University, vermicomposting was promoted for the benefits of the target populations in different villages in and around the university. Beneficiaries were provided the literature published in local language.

Integrated Farming

Biotechnological interventions through integrated farming were implemented by Shri AMM Murugappa Chettiar Research Centre (MCRC), Taramani, Chennai to provide alternative income to SC/ST targeted population. Various interventions viz. vermicomposting, mushroom cultivation, charcoal briquetting and clonal propagation were introduced and established vermicompost pits, mushroom cultivation sheds, charcoal briquetting units, net houses. About 664 beneficiaries covering 160 villages through networking partner NGOs were trained on income generation activities in addition to their present occupation. Adaptation of biotechnological interventions by the beneficiaries gained alternative livelihood interventions through utilization of the locally available resources.

Organic Cultivation of Spices

Peermade Development Society, Kottayam has implemented a project on cultivation of pepper for the tribal farmers of Idukki district of Kerala. Fifty tribal farmers from different Self Help Groups were provided training on the scientific organic management of pepper with combined use of different biological control agents, biopesticides, botanicals and trap crops. Trichoderma and Pseudomonas formulations were supplied to the farmers for application in their crops. Farmers trained on vermicomposting, multiplication of VAM and production of neem seed kernel extract and also provided small vermicompost facilities for production and use in their fields and regular monitoring of their field crops. Demonstration plot was established under the project to carry out the farm trials for the efficient organic control of pests and diseases.

Medicinal and Aromatic Plants

Programme was undertaken on Empowerment of SC/ST community of Bundelkhand region by introducing the cultivation of medicinal and aromatic plant and processing through CIMAP. Ten farmers each from two bio-villages of Jhansi were trained on raising the nursery of Palmarosa and Lemongrass. Distillation/processing

unit were centrally set up. Kisan awareness programmes were organized for the farmers of adjoining villages also for wider adoption of these crops and also trained to adopt rainfed cultivation of medicinal plant. SHG groups were formed to sensitize the farmers to take up commercial cultivation.



Fig. 5.3: Interaction with the farmers on cultivation of MAP

Mushroom Cultivation

Entrepreneurship development programme on Oyster Mushroom Cultivation was introduced for SC/ST target population in Tiruchirappalli District by Bharathidasan University, TN. Spawn production laboratory was set up and 50 selected trainees were provided hands on training on mushroom cultivation, spawn preparation, bed preparation, diseases prevention and marketing. A training manual prepared in local language distributed to the participants. Some of the entrepreneurs

trained have already initiated commercial mushroom cultivation.

Programme for Rural Development

The programme was continued for the socio-economic upliftment of rural population. Various training and demonstration programmes in biotechnology based activities were undertaken on proven and field tested technologies relating to quality planting material, bio-control agents, vermicomposting, organic pepper cultivation, lac cultivation, sericulture, animal husbandry, goat rearing, quail production, rabbitry and health care etc. Demonstrations and trainings activities undertaken could benefit the rural people through various biotechnological interventions. The department supported eight bio-events to exhibit various rural products & processes for their promotion & adoption at the rural level. Some highlights of the programme area are as follows:

Quality Planting Material

A project on Developing Quality Planting Material Resource Nodes for Medicinal and Aromatic Plants (MAPs) was implemented in villages of Sitapur, Barabanki and Lucknow districts in U.P. through Agro and Nursery Technology by CIMAP, Lucknow

so that authentic planting material could be supplied to the interested growers and set up centrally located distillation unit. Hands-on training was imparted to around 130 interested growers on the agro and nursery technologies of selected MAPs and vermi-technology. Demonstrations conducted in 34 villages, and farmers earned a substantial profit both from sale of planting materials and production of oil/herbs from various medicinal and aromatic plants.

Bio-control agents

A project on popularization of bio control agent was undertaken by Indian Institute of Pulses Research (IIPR), Kanpur to provide benefits to the farmers of Bundelkhand region of UP. Awareness campaigns were organized on pod borer (*Helicoverpa armigera*) management. Farmers were given hands on experience on application of HaNPV and NSKE in the chickpea crop and monitoring of pod borer population. Demonstrations were organized for pheromone traps, spray of neem based product, spray of HaNPV, spinosad for monitoring of pod borer, for repelling egg laying, management of early and late instars in 20 ha benefitting about 90 farmers.

Amity University has undertaken a training programme on eco-friendly integrated management of major soil born fungal and

root knot nematode diseases infecting vegetables. About 264 selected farmers were trained from western U.P. through awareness programmes on management of root-knot nematode infecting vegetables. Eco-friendly, cost effective disease management using sustainable components like antagonistic fungal bio-agents (*Trichoderma spp.* and *paecilomyces lilacinus* as core component), oil seed cake and botanical antagonist were demonstrated at hot spots with indigenous technology. The IPM package significantly helped in improving seed germination and yield increase from the crops. Farmers made the fungal bio-agents themselves, applied in their own fields and got good result.

Vermicomposting

A project on vermicomposting was implemented for the Socio-economic Development of Rural people from Bangalore District, Karnataka. A total of 146 demonstrations on vermicompost production were conducted for the beneficiaries. Beneficiaries were trained on preparation of vermicompost units, introduction of earthworms, watering and maintenance, protection against ants and rodents, collection of vermicompost, processing and preservation and preparation of vermi-wash. Continuous monitoring support was extended to the beneficiaries

throughout the project implementation. The efficacy of vermicompost was assessed on brinjal, chilli and ragi crops. The demonstrations benefitted more than 1000 farmers. A pilot training Centre was established at the campus to provide inputs and training. More than 200 PG students have also trained on vermicomposting and also use this unit for converting waste into vermicompost in nursery.

Organic Pepper Cultivation

A project on scientific cultivation and value addition of pepper to increase agricultural income of the marginalized farmers in Udumbanchola Taluk of Idukki district was undertaken by Kottayam Social Service Society, Kottayam. A laboratory was established at Thadiyampadu, Idukki District for multiplying the *Trichoderma* and VAM fungi to control the Quick-Wilt disease in Pepper. About 227 farmers were trained on rapid multiplication technology of pepper, biological control agents production and value addition. Trained farmers realized good income through adoption of micro-propagation technology and organic cultivation of pepper. A central nursery was set up at its regional in Idukki district to produce disease free pepper. Rapid multiplication technology was used and disease free plants were distributed among the marginal farmers to set up their own

nursery. Farmers were trained on processing of white pepper production and they are earning a better price of Rs. 160/- per kg for white pepper while green pepper fetches only Rs. 80/- per kg.

Lac Cultivation

Lac cultivation was popularized for economic upliftment of marginal farmers in Kandi belt of Jammu, J&K. Awareness and motivation programme was organized and on-farm trainings conducted at zonal or district levels in Jammu, Kathua and Samba districts for the potential growers to take up lac cultivation on regular basis. About 234 potential growers were identified where adequate potential for lac cultivation exists, *i.e.* vicinity of forest and availability of useful trees. Five field demonstrations were conducted and 43 farmers were trained on state of art technology on lac production including pruning, inoculation, crop protection and lac processing and brood production on *Palas* and *Ber*. Two hundred trees of *Palas* and *Ber* were inoculated, which yielded about 334 kg of brood for inoculation. Seven farmers adopted the technology and started earning with more than 100 days employment per annum.

Sericulture

CSRTI, Mysore is pursuing a project on

popularization of Chawki Rearing Center (CRC) model developed by CSRTI, Mysore in identified clusters of Karnataka, Andhra Pradesh and Tamilnadu. CRCs were established in identified cluster areas and training programme were conducted for the selected entrepreneurs and their workers on Chawki garden and Chawki rearing management. Progressive sericulture farmers were supplied chawki reared worms in co-ordination with the State Departments of Sericulture Karnataka, Andhra Pradesh and Tamilnadu. Ten days certificate training programme on commercial CRC maintenance and management for CRC owners were organized at CSRTI, Mysore. CRC owners started earning regular income and are repaying their loans through sericulture activities.

Artificial insemination

Tharparkar breed of cows one of the high milk yielder in India is mainly reared in desert area of Rajasthan. This cow is on an average producing 2179.43 ± 16.76 kg milk during full lactation period of average length as 314.78 ± 5.23 days. Five bull calves of Tharparkar breed were selected from Central Cattle Breeding Farm (CCBF), Suratgarh and monitored for their growth till the semen collection age by BAIF foundation for desert areas of Rajasthan. Door step breeding services were provided

to the livestock owners extending artificial inseminations service to 2508 cows and confirmed 1,013 pregnancies. Around 700 farmers' were trained on new technologies of general cattle management practices. The popularization of the A.I. among the farmers especially those who are keeping Tharparkar animals raised the confidence level in dairy business.

Goat rearing

Project on dissemination of technology on Berari goat rearing was successfully implemented for Socio-economic upliftment of farmers and youth of ten villages of suicide prone Akola district of Maharashtra. 59 hands on training and demonstrations were conducted benefitting 680 farmers. For reducing mortality and morbidity rate in goat due to diseases, 51 goat health camps were organized in villages in which vaccination and deworming of goats were undertaken. Berari goat unit of two female and one male were distributed to 50 beneficiaries on 75% subsidy basis. The beneficiaries have started earning around Rs. 800 /month through sale of goat, milk and manure. Training manual of book and leaflets prepared in simple local language distributed to the beneficiaries.

Local non-descript breed upgraded with improved Osmanabadi proven to be useful

for enhancing the income of the small and marginal farmers. About 1154 beneficiaries were trained on the various aspects of goat farming and need based animal health care. Video show on field day was organized for motivating the farmers to take up the goat farming as an income generation activity. Three hundred bucks of Osmanabadi breed were supplied to the beneficiaries by KVK Durgapur, Amravati which gave them confidence and encouragement. Improved management practices adopted by beneficiaries resulted multiple birth, reduced inter kidding period and body weight gain at an early age.

Quail Production

Demonstration and training programme on commercial quail production was undertaken in rural areas of Parbhani district of Maharashtra by College of Veterinary and Animal Sciences, Parbhani. Mass awareness camp on quail farming was organized and demonstration of quail, egg and meat production was conducted benefitting around 100 women farmers. Scientific knowledge on Japanese quails farming disseminated to the women beneficiaries covering preparation of cages, feed, vaccination, incubation, marketing etc. Cost economics per unit of quail for meat and egg production worked out which indicated economic viability of quail production to

gain an income about Rs. 3000 to 4500 per months. The intensive training was imparted on commercial quail farming in Parbhani district. A booklet was brought out on quail farming for distribution among the beneficiaries.

Rabbitry

Amity Institute of Phytochemistry and Phytomedicine Trivandrum conducted training programme on Rabbitry and Fur Processing for the benefit of SC/ST youths of Trivandrum District, Kerala. A model Rabbit Farm and Training Centre was set up in Kodunganoor Village and three units of breeding stock of rabbits consisting of 10 females and 2 males to each beneficiary provided which facilitated breeding rabbit strains of New Zealand White, Soviet Chinchella and Grey Giant.

Health & Awareness

A school programme named Health Safari was successfully implemented by GAMANA, Hyderabad- Andhra Pradesh in collaboration with Mass Awareness Society. The project involved health check-ups of school children with the help of health department. The health check-up programme collected data on growth monitoring (BMI), dental hygiene, occurrence of diarrhoea and acute

respiratory diseases. It also covered assessment of sanitation and hygiene conditions of the schools and drinking water. Early detection of health related problems in children and their proper treatment through referral services were undertaken. Assessment made on quality of the mid day meal distributed in the school and provided special aids as medicines, spectacles, hearing aids etc. to the needy. Health Cards prepared and updated of child health profiles to be maintained in school. Distribution of posters and campaign leaflets to disseminate information on health/hygiene etc. Students and parents were given counselling on health care aspects. The project has benefitted more than 1,50,000 children studying in MCD schools of Delhi along with slum kids.

A project on awareness creation among the doctors and women of rural people was undertaken for preventable causes of mental retardation in new born babies through collaborative efforts of Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow and Chatrapati Shahuji Maharaj Medical University, Lucknow. An awareness creation programme for preventable causes of mental retardation, namely; congenital hypothyroidism, biotinidase deficiency and galactosemia was undertaken and the population from rural and lower / lower middle socioeconomic class were screened

by organizing camps in collaboration with district Hospitals and NGOs working in the health sector. About 4000 neonates have been tested for these three disorders.



Fig. 5.4 : Health safari project implemented at NDMC Schools

Information brochure and pamphlets were prepared in local language for distribution among the parents. A feedback received about the usefulness of new born screening programme undertaken. Most of the families coming for retesting their babies indicating their commitment. The project is now operating in a full swing and likely to test more than 15,000 babies.

Soya Milk Processing:

Training on soybean processing and its utilization for employment generation among weaker section was undertaken in Amravati District by KVK, Durgapur





कन्जनाईटल हाईपोथायराइडिज्म से प्रभावित बच्चा सही समय से इलाज होने से पूर्णतः सामान्य स्तर में विकसित हो रहा है।



कन्जनाईटल हाईपोथायराइडिज्म से प्रभावित बच्चा समय से निदान ना होने के कारण मंदबुद्धि का शिकार हो गया।

बच्चे का भविष्य आपके हाथ में है। नवजात शिशु की निम्नलिखित बीमारियों के लिये जन्म के बाद तीसरे दिन जाँच जरूर कराइये।

1. कन्जनाईटल हाईपोथायराइडिज्म
2. फेफोडिनिज की कमी
3. गैलेक्टोसीमिया

रिपोर्ट जानने के लिये सातवें दिन निम्न लिखित फ़ोन नम्बर: 0522 -2495210, 2494383 पर सम्पर्क करें।

Fig. 5.5 : Screening of new born babies for mental retardation

Amravati, talukas namely Nandgaon (Kh) and Bhatkuli. A society called Soybean Processors Society consisting 152 members was formed. All together 58 beneficiaries from these two talukas were trained for soybean processing. The trainee from said villages started producing the noodle and papad from soy flour and also soy milk, soy paneer successively which are being sold in the local market.

Bio-events

Eight bio-events were organized by various agencies namely D. S. College Aligarh, JSS, Mahavidyapeetha, Mysore; VKS, Krishi Vigyan, Unnao; Centre of Technology & Entrepreneurship Development, Sultanpur; Kottayam Social Service Society; Suvide Foundation, Washim; Dhanalakshmi Srinivasan, College of Arts and Science for Women, Perambalur, TN and Deendayal Krishi Vikas Avam Anusandhan Samiti, Bhopal (MP) for Awareness Creation and Promotion of Biological cum agricultural inputs and value added products among Self Help Groups. Through this programme awareness was brought among farmers on new agricultural practices, tools etc. to enhance their agriculture produce and cottage industry. About 5,00,000 people participated in the Bio-events with the involvement of governmental and non-government institutions.

Programmes for Women

Around 10,000 women have been benefited through various ongoing and new projects supported under the Programme. The programme is basically women-centric and covers training, field demonstrations, extension activities, enterprise development etc. in the subject areas such as horticulture, mushroom cultivation, biofertilisers, biopesticides, aquaculture, animal husbandry, poultry farming, production of diverse value added marketable products which may facilitate women to improve their income and socio-economic status. The programme also supports research projects focused on women health care, nutrition and hygiene related aspects. During the year, nearly 30 ongoing projects have been already supported. In addition, 7 new projects have already been sanctioned and 5-6 more are likely to be supported during the year. Highlights of the programme are as follows:

Vermicomposting and Organic farming

Nearly 2000 women farmers of Tiruvallur district in Tamil Nadu were imparted training on preparation of vermicompost and botanical pesticides. Each women beneficiary is reported to earn around Rs 3500 / p.m. through sale of vermicompost and neem oil formulation. Application of

these products by women farmers in their own fields has also been reported to reduce use of synthetic pesticides. Approximately 900 farmers of Chamba district in Himachal Pradesh were trained on vermicomposting and 150 farmers were provided with the necessary inputs to set up vermicomposting units in their fields.

Mushroom Cultivation

In a project supported in Jammu & Kashmir, two mushroom training cum demonstration units were conducted in district Burdgam and nearly 160 women were trained on laying of spawn, casing and picking, packing, preparation of different mushroom based recipes. The trainees were also encouraged to use the spent compost as fertilizer in their paddy fields and kitchen gardens. At Bangalore, training has been imparted to nearly 200 rural women on Mushroom



Fig. 5.6: Flush of Mushroom Fruiting at one of the beneficiary unit in J&K

cultivation and its significance in income generation and nutritional benefits to target community. At Theni district in Tamilnadu, a spawn production unit has been established for production & distribution of spawns to the beneficiaries. Nearly 450 women beneficiaries have been trained on mushroom cultivation and production of value-added oyster mushroom products. A co-operative society of mushroom growers is also being registered to facilitate the start-up of micro-enterprises.

Aquaculture

A project on development of mangrove based agro aqua farming for restoration of Mangrove ecosystem and also for providing livelihood was supported at Port Blair. A demonstration pond was constructed at a farmers' field in Indira Nagar, South Andaman with provision of allowing entry of nutrient-rich water during high tide. 500 mullet (*Mughil cephalus*) seeds with an average weight of 10 gm. were stocked in the ponds and horticultural crops like banana, pumpkin, bottle guard were raised on the bundh. The fish grew to a mean weight of 64.54 ± 4.54 g and length of 13.09 ± 0.46 cm during four months while the culture was still underway. A total of 85 farmers have been trained on mangrove based agro-aquafarming.

Women fish farmers were trained on techniques related to fish seed production of Indian major carps, Catla, Rohu and Mrigal and also common carp at Raipur (Chhatisgarh). Training on plankton production for spawn raising, simple method to check water quality, rearing of spawn to fry and fry to fingerling was also given to the women fish farmers.

Sericulture

About 140 women beneficiaries from Annur, Udumalpet and MGC Palayam blocks in Tamilnadu were trained on scientific methods of sericulture. Application of biofertilizers viz., *Azospirillum* & *Phosphobacteria* enhanced the mulberry plant height (125.44cm), number of branches / plant (16.90), number of leaves/ plant(19.92) and leaf yield. The leaf yield per harvest was 7154.81kg/ha/harvest when compared to 5509.49kg/ha/harvest in control and resulting in an additional income of approx. Rs.2100/ha/harvest. Using IPM package consisting of TNAU botanical formulation, uzitabiet and *Nesolynx thymus* (along with nets on windows and doors) for the management of uzifly, larval mortality was reduced to a greater extent and the cocoon yielded more than double (from 29.40 kg/100 dfls to 77.36 kg/100dfls) resulting in an additional income of around Rs.7000/100 dfls. The use of Phytojuvenoid

("Ilamathi") on silkworm for increasing the silk yield enhanced the larval weight, cocoon weight, shell weight, shell ratio and the larval duration.



Fig. 5.7 : A women beneficiary applying *Nesolynx thymus* biocontrol agent for silkworm uzifly management

Livestock farming and Poultry

Around 200 tribal women beneficiaries from 30 viable SHGs in Senapati district of Manipur were trained on pig rearing, their housing, feeding, healthcare management and breeding etc. Each women beneficiary was given 2 weaned piglets along with veterinary medicine and the provision for construction of pigsties. The piglets were vaccinated against "swine fever". Farrowing has been observed in adult sows and the beneficiaries have started to earn income from the sale of piglets. Another project was supported in Parbhani district of Maharashtra to train 250 women on goat

rearing by adopting osmanabadi goat, an improved breed.

Bee Keeping

In Chamoli and Rudraprayag districts of Uttarakhand, hill women are being encouraged towards beekeeping and they are being educated on the importance of honey, bees and other bee-products such as bee-wax, royal jelly, bee-bread and role of honey bees as pollinator in increasing crop yields. A total of 40 women beneficiaries have been trained and provided with Bee boxes, colonies and necessary equipments. Honey extracted from 29 boxes in summer season had shown an increased yield upto 2.0 kg/hive. Six honey samples were analyzed for their physico-chemical properties which fulfilled Grade 'A' standards. As a part of the project, 92 bee-forage plant species were identified from



Fig. 5.8: Women beneficiaries trained on bee keeping in Uttarakhand

area to be good sources of nectar and pollen for bees.

Quality Planting material

A total of 300 farm women were trained on raising crop with CORH 3 hybrid rice seeds and systemic rice intensification (SRI) techniques. An average rice yield under SRI with hybrid was 2896 kg/acre (7.25 t/ha) which is 46.74 % higher than the variety under normal method yielding only 2073 kg/acre (5.2 t/ha). The additional income for the farm women ranged from Rs 5,000 to Rs.15,000.

In Raipur and Durg districts of Chhattisgarh, 66 women from 4 villages were trained on maintaining seed health, storage, processing and treatment etc. Under the project, the crops selected for quality seed production were chickpea and three rice varieties viz., MTU 1010, Mahamaya and Karma Masuri.

In Senapati district in Manipur, Krishi Vigyan Kendra is promoting Kiwi fruit plantation among the women farmers and conducted 10 demonstration cum training programme on cultivation of organic kiwi plantation. So far, 50 hectare area has been covered with kiwi sapling and other inputs provided under the project which benefitted around 100 women farmers.

Value added Products

Women (200) in Amravati district were educated on processing of soybean and its importance in nutrition and alleviation of malnutrition. Hands-on training were also imparted for removing anti-nutritional factors from the soybean and on preparation of various traditional fermented products. In addition, there were 450 women trained at Dharwad on value addition to various non-forest timber products (NTFPs) for their better income.

Healthcare

In Burdwan district of West Bengal, more than 3800 women were screened for cervical cancer using visual inspection with acetic acid (VIA) method. A total of 585 VIA positive cases were detected showing white lesion in their cervix. Amongst them 47 cases of high grade precancerous lesion (CIN grade II & III) were detected and treated by Loop electrical excision procedure (LEEP). Cervical Intra-epithelial neoplasia grade I (CIN I) lesion could be detected in 251 cases. A total of 41 cases of condyloma/polyp were also treated. The investigators are making their efforts to negotiate with the Health department of the State Govt. to make the cervical screening programme as a part of the district cancer control programme.

PGIMER Chandigarh registered around 250 women suffering from Uterine incontinence (UI) and pelvic organ prolapse, for their behavioral therapy (BT) and trained them in Kegal exercise. It was reported that more than 75% women had relief in the symptoms experienced by them. To record and monitor the incontinence severity, a pad test was initiated and so far it is performed with 100 patients. A workshop was also conducted on Behaviour therapy for UI at PGIMER and published a booklet on UI in Hindi, English & local language and distributed among the project beneficiaries.

A project was supported on Systemic Lupus Erythematosus (SLE), a prototype autoimmune disease characterized by the production of range of auto-antibodies and a diverse set of clinical phenotypes occurring predominantly in females than males. Nearly 100 healthy age and sex matched controls were enrolled. Three codon polymorphisms of MBL genes viz. D (52), B (54) and C (57) were genotyped by RFLP-PCR and three promoter polymorphisms (H/L, X/Y and P/Q) were genotyped by Allele specific PCR and RFLP. However no difference was noted between disease severity and MBL gene wild type and/or variant allele in SLE patients. Allele frequency of promoter region variant alleles was observed to be slightly higher among the SLE patients.

As a part of a project supported to Kidwai Memorial Institute of Oncology, Bangalore, women with carcinoma of Cervix, Breast and Ovary were educated on importance of balanced diet and encouraged to incorporate poly unsaturated fatty acids (PUFAs) in their diet as a possible therapeutic substance capable of reducing cancer progression and inflammatory disorders. The fatty acid profiles in the membrane of RBCs in age matched women with or without cancer is also being studied alongwith the estimation of fatty acids in various tumor infiltrating immune cells.

SGPGIMS, Lucknow is pursuing a study to evaluate the efficacy of Vitamin D supplementation in middle and last trimester of pregnancy to maintain the optimum levels of maternal serum and cord blood 25 hydroxy Vitamin D levels, which in turn would help in analyzing the effect

of vitamin D on childhood respiratory health.

New Initiative

In addition, the department took a new initiative to take up a programme on '**Women Health, Hygiene & Nutrition**' under which projects will be implemented at community level for the benefit of large number of women. The programme would cover women reproductive health needs; cancer screening, awareness and management; chronic disorders as iron deficiency anemia, folic acid deficiency, osteoporosis, other micro-nutrient deficiencies & nutraceuticals based interventions, pre-natal genetic disorder screening and counseling etc. The projects will be implemented by medical institutions and governmental & non-governmental organisations.



BIOTECHNOLOGY PRODUCT AND PROCESS DEVELOPMENT

INDUSTRY SCHEMES

Small Business Innovation Research Initiative (SBIRI)

The 'Small Business Innovation Research Initiative (SBIRI)' is the pioneering programme of the department that supports R&D, process & product development in industry. During the present Plan Period, the SBIRI has made a mark in the biotech sector. The efforts of the department towards promotion of small and medium enterprises focusing on scientific innovations have been appreciated by the stakeholders.

SBIRI has helped many small and medium enterprises to establish proof-of-concept and to work on innovation R&D through its Phase-I funding through which the industries were supported primarily in the form of grants-in-aid. The scheme also supported industries towards late stage R&D resulting into process & product development through its Phase-II funding.

As in the earlier years, this year also three Road-shows were conducted at Kolkata, Mumbai and Kochi. The participation of the private sector was overwhelming. Such promotional activities and also advertising the scheme in National dailies as well as in local newspapers has resulted in a continuous flow of applications from various industries from all the corners of the country. Under the scheme, the Department has so far received more than 900 proposals and has sanctioned 105 projects. Around 540 industries throughout the country have approached the Department seeking support under the scheme. State-wise response to the scheme is indicated in Fig 6.1.

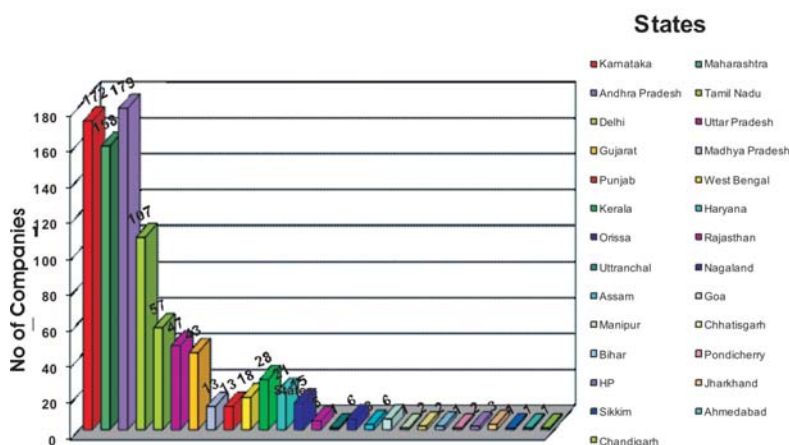


Fig. 6.1: State-wise response under SBIRI

During the current year the Technical Screening Committee (TSC) met 8 times to evaluate 114 new proposals received in response to two 'Call for Proposals'. 62 proposals were presented to the TSC. A total of 40 site-visits were conducted to various industries to assess their suitability for funding. The Apex Committee met 3 times to consider the recommendations of the TSC and to discuss various other policy issues regarding the scheme. Based on the recommendations of the Apex Committee, the Department has funded 19 new proposals in different areas in biotechnology and 10 others are in pipeline. A three tier review process was used to assess the progress in the ongoing projects *viz* submission of quarterly progress reports by the companies, half yearly on-site review by Project Monitoring Committees and yearly review by the TSC. Currently 52 projects are in operation. The details of the scheme and a list of the projects funded so far can be seen on the website: www.sbiri.nic.in.

Work on different projects has been progressed well. Based on the reports submitted by the industries and the reviews undertaken by the PMCs and TSC, the major achievements during the year are given below:

Agriculture and allied areas

The experimental protocol for assay of salinity tolerance in rice under simulated conditions has been optimized by M/s. Bioseed Research India Private Limited, Hyderabad in collaboration ICGEB, New Delhi. The donor rice lines and BC1, BC2, BC3 seed from five recipient lines carrying gly I & gly II were tested for salinity tolerance in simulated conditions and out of 5 events, event B6 has consistently displayed salinity tolerance in different genetic backgrounds with no penalty on yield or plant growth. At M/s Rasi Seeds Private Limited, Attur, a transformation protocol to generate transgenic *cassava* lines using gene constructs containing replicase RNAi genes was standardized and the putative transgenic cassava plants hardened in green house are being analyzed. Marker free anti sense AV2 transgenic cotton plants have been developed and were evaluated in the field of M/s Maharashtra Hybrid Seeds Co. Limited, Jalna in collaboration with IISc., Bangalore. M/s Bejo Sheetal Seeds Private Ltd., Jalna is working on Bt Brinjal expressing modified *cry 1Fa1* gene and Bt Tomato & Bt Okra with *cry1 Ac* gene. A micropropagation facility to produce 1.5 million plantlets of *Jatropha curcas L* per year has been established at M/s Labland Biotech Private Limited, Mysore. Production of hardened net pot

plants and poly bag plants is underway done. The liquid and wettable powder formulations viz 'Helimar' (*Helicoverpa armigera* NPV) and 'Spodomar' (*Spodoptera litura* NPV) have been developed and commercialized by M/s Multiplex Biot-Tech Pvt. Ltd., Bangalore. ELISA kits for detecting Cry1Ac, Cry2A, Cry1F, Chinese fusion BT, Dow Cry1Ac have been developed and commercialized by M/s Amar Immunodiagnostics Pvt. Ltd., Hyderabad.

Health sector

A production process for 500 L fermentation batch of recombinant fuzeon under the trade name 'Defuse' for treatment of AIDS has been optimized by M/s Virchow Biotech (P) Limited, Hyderabad and the product is in the clinical phase of development. In another project the company has commissioned the production facility for recombinant uricase (trade name 'Rasburicase-Tuly') used in treatment of hyperuricemia. Toxicology studies have been completed using in-house developed recombinant protein. The production process has been scaled up to 100 Lt. The yield of the product was 200 mg/ L and batch size is 3000 to 4000 vials per batch. Human trials to study the effectiveness of the recombinant uricase are under progress. HRP-II/ p-LDH based diagnostic kits for

differential detection of malarial parasites has been developed by M/s Bhat Biotech India Private Limited, Bangalore in collaboration with NIMR, New Delhi. Two cocktails consisting of six monoclonal antibodies have been screened and characterized by M/s Mediclone Biotech Pvt. Ltd, Chennai and found them equivalent to polyclonal antisera, which is commercially available for snake bite treatments. M/s Cadila Pharmaceuticals Ltd., Ahmedabad have studied the effect of co-immunization of *Mw* with rabies vaccine. The adjuvant effect of *Mw* was found to be dose dependent for rabies vaccine and the best immune response was found with 10^8 *Mw*. *Mw* manufacturing process in the GMP facilities set-up for commercial production has been standardized. Development of silkworm as a bioreactor for expression of recombinant aprotinin, peptidyl amidase and thrombin has been established by M/s Enzene Biosciences Pvt. Ltd., Bangalore.

Industrial processes & products

M/s Bharavi Laboratories Pvt. Ltd., Bangalore has developed a technology for production of drug intermediate (S)-3-hydroxybutyrolactone from maltodextrin and a value added product (S)-4-hydroxy-2-pyrrolidinone using the enzyme pullulanase for yield improvement and the whole purification process was standardized

without chromatography and distillation. Through this indigenous innovative technology they are able to price their product at \$ 500/Kg as against the Aldrich's cost of \$ 160/g. M/s India Pesticides Ltd., Lucknow has optimized the process for the preparation of curcumin- piperoyl conjugate. Pure synthetic curcumin production on a large scale (4 kg/ batch with 99% purity has been achieved. Pilot scale process for dextranase production for sugar industry has been standardized and a product 'Dextrasol' is ready for its further scale up by a small industry M/s Varuna Biocell Pvt. Ltd., at Varanasi. M/s Privi Organics Ltd, Navi Mumbai has developed eight aroma esters through the biotech route and developed a commercially viable technology that can be easily scaled up. M/s Hydrolina Biotech Private Limited, Chennai has standardized a pilot scale process for extraction of lycopene from 'Navin' varieties of tomatoes in Tamil Nadu and a commercial scale is in the process of establishment. Units for extraction of value added products from crustacean exoskeleton and coir-pith integrated zero discharge processing are being commissioned in Tamil Nadu and Kerala by M/s Pelican Biotech and Chemical Labs Pvt. Ltd., Kerala.

Bio-instrumentation

At M/s Span Diagnostics Limited, Ahmedabad, a pilot batch of 15 newly

designed clinical chemistry analyzers named as 'Ingenious' is ready, consisting of 1135 parts in each and 359 among them are unique. Performance evaluation of these analyzers was also done using absorbance standards and clinical samples. The company hopes that the product would be priced at a very affordable rate compared to the imported analyzers. M/s Perfint Healthcare Pvt. Ltd., Chennai have developed a platform of medical tool positioners for use in Image Guided Interventional Procedures as an accessory to C.T. Scan to help in performing CT guided diagnostic and therapeutic procedures like biopsies, FNAC, ablations and pain management procedures and is of immense use in early stage small and difficult lesions in lung, abdomen and bone. PIGA CT guided system is being evaluated clinically in hospitals across India and the response to it has been very favorable. Newer models of the 'Automated Dispensing System' designed indigenously and validated by M/s Customised Technologies Private Limited, Bangalore.

Bioinformatics

Two novel compounds, computationally designed and synthesized by M/s Oxygen Healthcare Research Pvt. Ltd, Ahmedabad, have been demonstrated for efficacy as H3 and GPCR ligands based on preclinical data

and PK results obtained on animal models. The development of tools of bioinformatics by M/s LeadInvent Technologies Pvt. Ltd., New Delhi in collaboration with All India Institute of Medical Science, New Delhi on design and development of inhibitors for the treatment of tuberculosis showed promising results with novel compounds that exerted activity against devR, which is a transcriptional regulator that mediates the genetic response of *Mycobacterium tuberculosis* to oxygen limitation and nitric oxide exposure.

A graphical representation on the projects funded under SBIRI in different areas of biotechnology is given in Fig 6.2.

Biotechnology Industry Partnership Program (BIPP)

The Biotechnology Industry Partnership Programme (BIPP) an Advanced Technology Scheme only for high risk, transformational technology/process development was approved by the Cabinet in November 2008. The scheme is a government partnership with Industries for public support on a cost sharing basis for

- Path-breaking research in frontier futuristic technology areas having major economic potential and making Indian industry globally competitive and focused on IP creation with ownerships

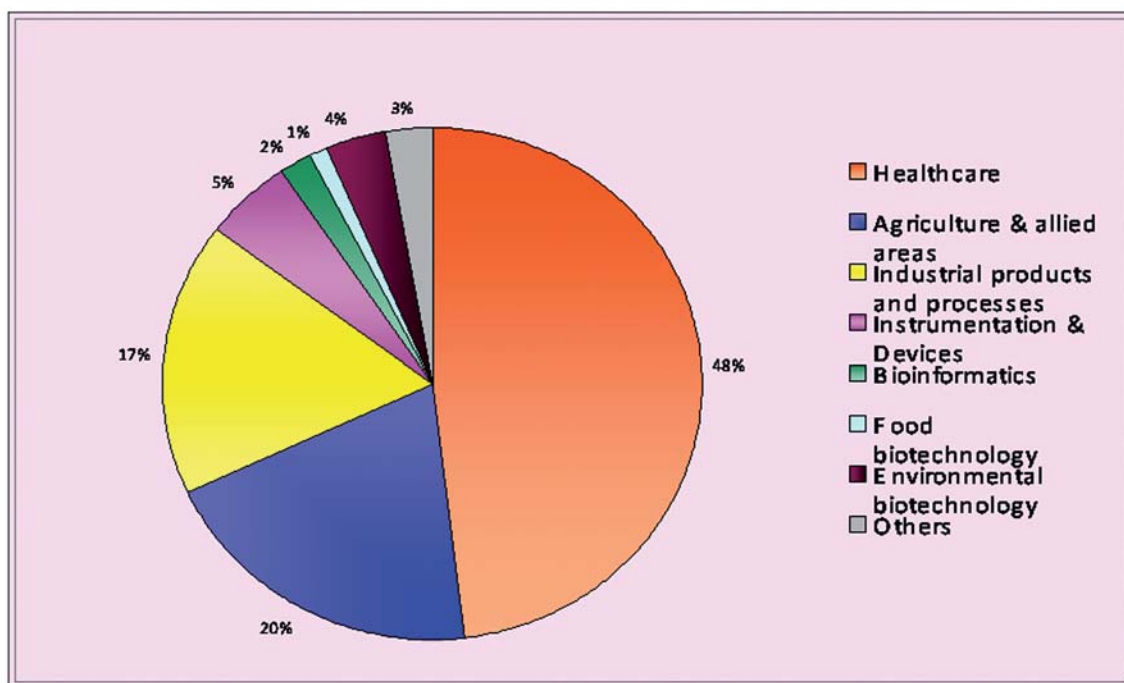


Fig. 6.2 Sanctioned Projects sector-wise

by Indian industry and where relevant, collaborating scientists.

- The development of appropriate technologies in the context of recognized national priorities in the area of agriculture, health, bioenergy, green manufacturing, when the scale of the problem has serious consequences for social and economic development.

Calls for proposals were invited in the areas namely H1N1 vaccine development, bio-similars, affordable healthcare technologies, anti-virals, secondary agriculture, value addition to agri-product for food and non-food application, industrial scale up of products and processes.

Under BIPP more than 700 proposals have been received out of which 63 projects were supported in the areas of Healthcare, Agriculture, Energy Infrastructure and also projects in PPP mode. Proof-of-concept research projects in medical biotechnology dealing with drug development and delivery systems, stem cell generation and clinical research have been funded and phase-III clinical trial of rotavirus vaccine has been undertaken.

Towards Commercialization

PandyfluTM (H1N1 vaccine) have been developed by Panacea Biotech and patent

has been filed. The DCGI has approved this vaccine as a two dose schedule. Phase III Clinical trials of JE vaccine has been successfully concluded by Biological E and has got the market license for India in the age group of >1 yr to 3year and >18 years to <40 years. A rapid cost-effective point-of-care diagnostic device with microPCR to diagnose multiple diseases presently Malaria, Dengue & Typhoid has been developed by Bigtec Pvt. Ltd. Bangalore and is ready for validation.

Service Facilities to promote Innovation

The facility set-up at Intas Biopharmaceuticals Private Limited, Ahmadabad is now ready for use by the Academia and Industry. Services are being provided to the academia at differential prices. A cGMP-compliant facility for bulk-production of monoclonal-antibodies for diagnostics as well as therapeutic usage and microbial antigens of diagnostic usage for providing contract-manufacturing services and specialized training to biotech personnel is being set-up at Span Diagnostics limited.

Highlights of some BIPP supported projects

Vaccine Development

In order to develop an affordable, Asia specific 15valent Pneumococcal

Polysaccharide - CRM 197Protein Conjugate Vaccine studies on one India specific serotype have been completed by M/s. Tergene Biotech Pvt. Ltd., Secunderabad: Small scale conjugation of polysaccharide from this 1 Serotype with CRM-197 in microreactor have been demonstrated.

Biomedical Devices

The study aims at developing a comprehensive solution of planning execution and control of the targeted ablation procedure by developing a planning platform – for 3D visualization and segmentation of tumor and organs, multi tool planning and ablation volume visualization; a robotic arm. The Integrated planning navigation and Training Platform for Tumor Ablation has been completed.

Clinical Trial

IND enabling toxicity studies of a new molecule Galnobax in rodent and non-rodent species for assessing safety for dermal application as well as chronic application of the product have been successfully concluded by M/s V-Life Sciences Technologies Pvt. Ltd., Pune. Studies are now continuing to take up phase I Clinical trial of Galnobax.

A molecule TRC150094 a novel Diiodothyronine (T2) analogue, for the

treatment of cardiovascular (CV) risk factors defined by Metabolic Syndrome (MS) aimed at increasing Resting Metabolic Rate (RMR) has been taken up by M/s. Torrent Pharmaceuticals Ltd., Ahmedabad. Phase I studies of this molecule have been successfully completed.

Diagnostics

Amar Immunodiagnostics Pvt Ltd., Hyderabad has developed an ELISA based diagnostic kit for celiac disease for detection of IgG and IgA specific antibodies to Tissue Transglutaminase (TTG).

A study by M/s Abexome Biosciences Pvt. Ltd., Bangalore aims to develop antibodies and assays that can be used for pharmacological characterization of the common biosimilar mAbs (monoclonal antibodies), viz. Rituximab, Infliximab, Adalimumab, Trastuzumab and Bevacizumab.

Bioenergy

An efficient lactic acid production from mango kernel by *Lactobacillus sp.*, in batch fermentation process has been demonstrated by M/s SPC Biotech Pvt. Ltd., Hyderabad. In order to develop Transformational Technology Platform for Biological Hydrogen, promising seedless hybrids of

Sweet Sorghum have been identified with high sugar high yield by M/s Nagarjuna Fertilizers & Chemicals Ltd. Bharat Petroleum Corporation Ltd. in collaboration with TERI has been working on a project aimed at development of process know how for butanol production from lignocellulosic biomass.

Biotechnology Industry Research Assistance Council (BIRAC)

The Cabinet has accorded approval for the setting up of “Biotechnology Industry Research Assistance Council (BIRAC)” as ‘not-for-profit’ section 25 company with a vision to stimulate, foster and enhance the strategic research and innovation capabilities of the Indian biotech industry particularly SME’s, to make India globally competitive in biotech innovation and entrepreneurship and to create affordable products and services.

BIRAC will operate with a core budget for its regular activities and recurring expenses for human resources and operational cost. BIRAC is being set up as a separate body for supporting product innovation and providing required infrastructure and services at different stages of the value chain for promoting innovation and product development.

BIRAC will provide funding/investment for early and late stage, including Small Business Innovation Research Initiative (SBIRI), Biotechnology Industry Partnership Programme (BIPP) and ignition grant, contract research in Industry for public institution innovation, technology transfer and acquisition in national priority areas, promotion of entrepreneurship, incubators, parks and clusters and SME empowerment measure schemes. The BIRAC will also provide support services for IP facilitation, legal support and contracts, regulatory and clinical trials, mentoring and capacity building. Initially in order to kick start BIRAC a pilot BIRAP (Biotechnology Industry Research & Development Assistance Programme) was established in November 2008.

Activities of BIRAP

Following specific activities to support research, innovation in the biotech industries have been undertaken for innovation funding, capacity building and mentoring programme, technology development programme, initiating technology acquisition, landscape analysis and technology mapping, support services for policy and analysis, legal and contracts, IP facilitation, regulatory and clinical advise etc.

Besides BIPP, BIRAP is equipped with the required staff which executed different

programmes on capacity building. BIRAP also initiated an electronic journal consortium with the help of DELCON (DBT Programme) to facilitate access to experts and industry to over 900 journals and scientific literature for necessary research back up. BIRAP is providing mentoring programme by supporting travel and other expenses of experts to facilitate access to important workshops, meetings and conferences and associate the mandate of BIRAP with them.

BIRAP as a strategic partner of the Stanford India Biodesign (SIB) programme which provides necessary facilitation for the validation and commercialization activities. Transfer of Technology for Biofortification of Banana from University of Queensland, Australia is also under process. Discussions are continuing with the Australian Group. BIRAP is facilitating the IP search, tech transfer agreement / contract development. BIRAP has partnered with the IP Cell in BCIL, and it is being strengthened to provide the services to the Academia groups and Industry.

Since BIRAC has been approved by the Union Cabinet it will be registered as Section 25 Company and activities going under BIRAP will then move under BIRAC. Process of registration of BIRAC has already been initiated. By the end of the financial

year its activities are expected to start. All the programmes under I&M Sector, DBT will be operated through BIRAC. Services required at different stages of the entire value chain, viz: early stage innovation research, product development, product validation and commercialization will be provided under BIRAC.

Capacity Building in IP Management

An IP Management and Technology Commercialization (IPM-TC) Cell has been supported at DBT-ICT Centre for Energy Biosciences at Mumbai.

Biotech Product & Process Development

Biotech Product and Process Development programme endeavors to promote the research efforts towards optimization and scaling-up of significant leads. The emphasis is on commercialization of the biotech products and processes for the benefits of the society. During the year, the Department had received 220 proposals, out of which 30 have been supported and 180 are under different stages of evaluation. Significant achievements of some of the projects are presented below:

IIT Delhi, in the process to create PAT based control scheme for chromatography unit

operation, create overall control scheme for the entire process, and demonstration of the benefits of the PAT control scheme. The study envisages developing realistic PAT systems for individual Bioprocessing unit operations that industry can implement. So far, the investigators have created critical quality attributes Granulocyte colony stimulating factor of rHu-GCSF defined analytical scheme and seven methods have been developed for it. High throughput resin screening protocol has been developed.

A work undertaken at IIT Gandhinagar, to eliminate use of supercritical CO₂, use sub-critical CO₂ for precipitation and stabilization of ultra-fine particles of active pharmaceutical ingredients in aqueous suspensions for Pharmaceutical applications.

In a joint collaboration studies undertaken on various aspects to provide an efficient cost effective process for the extraction/isolation of sweet glycosides from *Stevia rebaudiana Bertoni* plant at Osmania University and IICT Hyderabad. Attempts are made to improve the quality of the sweetness of stevioside by adding at least one natural sweetener (e.g. sucrose, glucose and fructose) by glycosidation of steviosides or by membrane separation of impurities to obtain high purity steviosides. So far, the investigators have developed a methodology using membranes in isolation and

purification of stevioside from the leaves of stevia with improved organoleptic property. Both semi synthetic and enzymatical process has been developed in synthesis of glycosylated stevioside.

AT IIT Bombay, work undertaken to investigate the genetic basis behind differential productivity in recombinant mammalian cells at a global level with a focus on protein secretion pathway in the endoplasmic reticulum. The investigators created a secreting CHO-K1 cell line of varying productivity as a model system to study protein secretion. A set of 5 stable CHO cell lines have been established on the protein secretion pathway. The kinetics of each cell line is studied along with gene expression and proteomic analysis. Major chaperones responsible for protein folding in the endoplasmic reticulum and UPR stress pathway are identified. Multivariate analysis has been performed to identify the important variables influencing productivity. A mathematical model is also built taking into account all the major reactions of the unfolded protein response pathway.

IIT, Madras aimed at bioprocess development for the production of ethanol and polyols by *Debaryomyces nepalensis* NCYC 3413. Different medium components are screened for the optimum production of xylitol and ethanol. Plackett-Burman

experimental design has been used to screen important medium components influencing the production of xylitol by *Debaryomyces nepalensis*. Scaling-up the production of xylitol upto 5 litre fermentor under the optimized conditions is under progress. Another group at IIT Madras is in the process to characterize a recombinant putative acetyl xylan esterase from the thermostable bacterium, *Thermotoga maritima* for potential industrial applications.

Collaborators from Lady Doak College, Karunya University, Vision Research Foundation, and Madurai Kamraj University Chennai are developing the matrices using short and medium chain length PHA produced by *Pseudomonas* sp. LDC-5. PHA production has been optimized purified and characterized. Biocompatibility of PHA based matrices has been established with 3T3 mouse fibroblast. Cytotoxicity assessment of purified PHA and PHA based matrices is carried out to ascertain the non-toxic property of PHA. *In vitro* analysis of matrices for the growth of continuous cell lines of human origin are in progress. Isolation of stem cells from human cornea is in progress and primary cultures of corneal limbal stem cells are being standardized.

University of Delhi is optimizing the process for Keratinase production from *Bacillus*

pumilus for degradation of recalcitrant proteins. The production of the enzyme has been optimized in different modified feather medium. Downstream processing of the enzyme has been carried out with an overall recovery of 84.74%. After purification of the keratinase, the characterization of the purified enzyme is being carried out along with its evaluation for degradation of yeast prion clone (Sup35NM).

IIT Guwahati, characterized the industrially important proteases from selected protease producing bacteria isolated from environmental samples of north-east India. Novel alkaline proteases from *Brevibacillus* sp.AS-S10-II and *P.tezpurensis* sp.nov.AS-S24-II have been isolated. An alkaline α -keratinase from *B.licheniformis* AS-S24-I strain has been isolated and its application in laundry detergent has been formulated. A process optimization for degradation of raw chicken feather using alkaline α -keratinase from *B.licheniformis* AS-S24-I strain has been evaluated.

Shri AMM Murugappa Chettiar Research Centre, Taramani, Chennai are aiming at mass cultivation of the fruiting bodies of different strains of *Ganoderma lucidum* at different climatic conditions, validation of nutraceutical properties in reputed / accredited National and International laboratories leading to formulation of

Ganoderma powder as potential products of nutraceutical importance.

Gulbarga University is attempting to develop dietary Nucleotides from Sugarcane for Therapeutic Applications. The highest concentration of nucleic acid has been observed in *saccharum officinarum*, *Glycin max*, *Phasleolus vulgaris*, *Phasleolus aureus*, *Phasleolus mungo*, *Saccharomyces crevisiae*.

ICGEB, Delhi has undertaken work on *in vitro* biosynthesis of antimalarial drug artemisinin via metabolic engineering of BY-cells.

Biotechnological Approaches for Food and Nutritional security

During the year emphasis was given to understand the beneficial role of probiotics for human health, food safety issue addressal, developing novel food products & processes, rapid detection kits for GM foods, utilization of agricultural residues for obtaining value added products and low cost nutrient food supplements.

Probiotics for human health

Work on the effect of probiotic on reducing intestinal inflammation, inducing clinical remission and restoring intestinal

permeability in patients with active ulcerative colitis in a double blind randomized placebo controlled trial is ongoing in PGIMER, Chandigarh. A total of 90 patients have been screened and 15 have been recruited in the trial so far. Two groups of patients received 450 CFU of VSL#3 and 3600 CFU respectively and each of these groups has a placebo treated control group.

Research on small intestinal and whole gut metagenome in patients with celiac disease is progressing at AIIMS and NCCS to study the metagenome of duodenal biopsies and whole gut metagenome in the stool of the treatment naïve patients with celiac disease, patients on gluten free diet for atleast one year, first degree relatives of celiac disease and controls.

ARI, Pune is working to develop a process for increasing resistant starch in selected food materials and to assess their pre-biotic and anti-inflammatory potential through *in vitro* and *in vivo* models. Ten cereals and pulses were subjected to retrogradation and three of them showed significant increase in resistant starch.

For enhancement of innate Mucosal immunity probiotics (*Lactobacillus acidophilus*, *Bifido bifidum* and *Bacillus clausi*) were used to treat murine macrophage RAW 274.6,

human monocyte THP-1 and intestinal Caco2 cells. Microarray studies of mRNA extracted from probiotic treated cells indicated that approximately 7000 entities showed 2 fold and higher changes in terms of expression.

NDRI is working on to understand the interaction of probiotics bacteria with innate and adaptive immune system to alleviate the immunological reactions in a neonate and aged animal model. Three probiotic *Lactobacillus* strains (*L.casei*, *L.acidophilus* and *L.helveticus*) were selected on the basis of probiotic attributes and used for preparing fermented milks. Preliminary results indicate that mice fed with milk fermented with *L.helveticus* recorded remarkably higher lymphocyte proliferation index compared to control and other probiotic fermented milk groups.

Probiotic for fetal immune programming an encapsulated combination of probiotic and prebiotic is being studied to see for any impact on fetal immune programming. Among 18 *Lactobacillus* strains tested, *Lactobacillus paraplantarum* 321 and *Lactobacillus helveticus* 194 inhibited the growth of all pathogenic bacteria under test conditions while, *Lactobacillus helveticus* 194 strain showed susceptibility to *Proteus*, *E.coli* ATCC and *Pseudomonas* species. *Bifidobacterium bifidum* 231 also inhibited the

growth of all pathogens tested except *Pseudomonas* and *Bacillus cereus*.

Probiotics for treatment of Bacterial vaginosis women with recurring episodes of vaginosis or vaginitis whose vaginal pH is above 5 were enrolled in the clinical trial which is being conducted at AIIMS and Sir Gangaram Hospital, New Delhi. The trial employs BASANT (a polyherbal microbicide consisting of curcumin, purified extracts of amla, purified saponins, aloe vera and rose water) dispensed either as a tablet or as capsule which is used every night for 14 days, initially to cure vaginosis or vaginitis.

Detection of Genetically Modified Foods (GMOs) and Food Products

Research at NBPGR, New Delhi is constructing a system of 96 well pre spotted plates for the individual detection of targets allowing the simultaneous identification of GM events by the use of event specific primers and probe combinations for detection of GMOs. Transgene/ promoter/ marker/endogenous gene specific simplex PCR based detection protocols have been developed for six GM maize events and four stacked GM maize event. Twelve GM Events, 5 Cotton Events and 7 maize évents along with their endogenous genes, were validated on the ready-to-use multi-target

analytical system with specific primers and probes. Event-specific Real time PCR protocols for Bt brinjal with cry1Ac, cry1Ab and cry1Fa genes have been developed.

Addressal of Micronutrient and Macronutrient deficiencies

Studies on development of multi-micronutrients fortified milk are underway for the assessment of the potential of toned milk as a vehicle for iron and vitamin A and calcium and vitamin D. The development of micronutrient fortified milk would be helpful in iron deficiency anemia in particular. BIBCOL has developed a product consisting of a mixture of seven minerals and thirteen vitamins as per WHO guidelines in a sachet aimed for treatment of severely malnourished children.

Development of Diarrhoea Management Combo Kit

A combo kit comprising of zinc tablets (14 tablets) and two sachets of ORS has been manufactured by BIBCOL. Scaling and automation of Zinc tablet production has been set up at BIBCOL. 30 lakh diarrhoea treatment kits have also been supplied to high burden North Eastern states for large scale demonstration.

Functional Foods

Development of Fermented functional foods from papaya

Studies are underway to isolate, characterize and evaluate the fermentative ability of endophytes of papaya fruit from four economically important varieties. The phylogenetic analysis based on the 16S rRNA sequence revealed that the isolated endophytes are genetically distinct and cluster as discrete clades in the dendrogram. Fermentative ability of the isolates was assessed and *Bacillus niacini* isolated from seeds of "Bangalore" variety utilized the fruit sugars and improved the antioxidant potential of the fermented product. The findings provide evidence that different parts of papaya fruits harbor an array of bacterial endophytes that could be important agents in attributing the high nutritive status to the fruit. These fruit isolates could serve as potent microbial cocktails for developing value added fermented products.

Bioactive Peptides

Toothpastes containing 4% Caseinophosphopeptides (CPPs) exhibited higher efficiency than those containing 3% CPPs in comparison to flouridated and control toothpastes. An *in situ* study on college students, on remineralization of enamel

lesion using sugar free chewing gums incorporated with 3% CPPs showed greater area of remineralization as compared to control chewing gums. A study on experimental rats for nutritional quality of weaning foods(WF) incorporated with hydrophilic, hydrophobic CPPs and control WF without CPPs, revealed an enhancement in 'bone mineral density' in weaning food with hydrophilic CPPs followed by those with hydrophobic and the control WFs.

Preparation of novel reduced calorie fats

Two structured lipids (SL-1 and SL-2) were prepared by inter esterification reaction using lipase enzyme. Both the structured lipids contained significant amounts of behenic acid and linoleic acid. The serum triglyceride levels were lowered significantly in rats fed SL- 1and 2 compared to that in rats given sunflower oil. The caloric value of SL- 1and 2 were lower in comparison to sunflower oil. The differential calorimetry scanning studies indicated similarities in thermo physical properties between bakery fats and SL- 1. Bakery products, such as cakes and biscuits were prepared by replacing bakery fats by structured lipid. Low calorie bakery products which are free from trans fats could thus be prepared using structured lipids.

Human Resource Development in Food Science and Technology through Integrated Master's and PhD programme

Integrated Masters and PhD programme was initiated by DBT in Anna University Chennai; Banaras Hindu University, Varanasi; IIT-Kharagpur and University of Kashmir, Srinagar. The research priorities in the above 4 institutions focus on fluid foods including dairy foods, fermentation technology, vegetable processing technology, processing of foods of plant and meat origin, food processing engineering, fermentation and bio-processing engineering, extension of shelf life of food items, fortified ready to eat products.

New initiatives

Medical Management of Children suffering from Severe Acute Malnutrition

Sever Acute Malnutrition without complications (SAM) are an acute state of severe wastage in under 3-yr age children, where the body mass is retarded particularly in relation to height. SAM is an important cause of morbidity and mortality in children below 5 years of age in India where approximately 8.1 million children are estimated to suffer. Up to 15% under the age of five, children with SAM require

inpatient management because of medical complications. The remaining 85% (without medical complications) can be managed through a community and or home based care approach.

An alliance has been formed among Departments of Health Research (DHR) and Biotechnology (DBT), and Ministry of Health and Family Welfare of the Government of India to support research to generate evidence for development of practical and scalable regimens to medically rehabilitate children suffering from SAM without serious complications at home/community level and/or at peripheral inpatient facilities.

The department has taken an initiative for identification of children in the community who have SAM without complication for which the proposals were invited in joint collaboration with the Departments of Health Research and Ministry of Health and Family Welfare of the Government.

Biosafety Issues

In compliance with the Rules-1989 of Environment (Protection) Act, 1986 (EPA-1986), the Department has reconstituted the Review Committee on Genetic Manipulation (RCGM) to evaluate, approve and monitor the safety related aspects of new and ongoing rDNA projects and research

activities involving GE Organisms and contained/confined field experiments of GE crops, insects and trees. During the year, RCGM has taken several new initiatives for the promotion of r-DNA technology in the fields of agriculture and pharmaceuticals and provided technical advice to GEAC to enable the facilitation of decision making on GMOs/ living modified organisms (LMOs) and products thereof for releasing them into the environment and for subsequent commercial use.

During the year, the RCGM considered about 800 applications in twelve meetings in the areas of agriculture, pharmaceuticals and industrial products for import/exchange of GE materials including transgenic seeds, gene constructs, plasmids, vectors, and GMOs/ LMOs; conduct of pre-clinical toxicity studies on innovative new drugs (IND)/similar biologics; evaluation of pre-clinical study data on IND/similar biologics, conduct of Biosafety Research Level 1 (BRL1)/ event selection trials in confined conditions on several GE crops of new genes or events developed by public/private institutions/companies for generation of biosafety data; and conduct R&D in pharmaceutical and agricultural areas. R&D activities are continuing on various other crops like rice, okra, brinjal, mustard, tomato, cabbage, cauliflower, ground nut, pigeon pea, chick pea, cowpea, finger

millet, sunflower, soybean, bamboo, castor, wheat, black gram, black pepper, chilies, onion, papaya, rubber etc. Eight public/private institutions/seed companies were permitted to conduct confined field trials of five GE crops viz., brinjal, cotton, rubber, corn and mustard containing new genes/events with the approval of RCGM & GEAC. Transgenic tree species like rubber, and transgenic insects like silk worm and mosquitos are on fast track of development. List of approvals accorded for conduct of confined field trials of BRL-1 on GE crops developed by public/private institutions/seed companies within the country is given in Table-6.1. Eleven Central Compliance Committee (CCC) teams constituted for monitoring the BRL-1 confined field trials on GM crops conducted by private/public sector institutions & companies. Department participated in 'Event based approval mechanism (EBAM)' for commercialization of transgenic Cotton Hybrids, Standing Committee constituted by Ministry of Environment & Forests. Based on the approval of the Standing Committee 142 transgenic cotton hybrids expressing four approved events were recommended to State Agriculture Departments for commercialization under EBAM.

In the pharmaceutical sector, 26 rDNA products were approved for conducting pre-clinical toxicity studies by 16 private/

public/autonomous institutions. Information on the healthcare products approved by RCGM for conduct of pre-clinical toxicity studies during 2011 is given in Table-6.2. Based on the pre-clinical study reports, 18 rDNA products developed by 11 private/public institutions & companies were recommended by RCGM to DCG(I) for appropriate phase of clinical trials. Table 6.3 gives the details of rDNA products recommended by RCGM to DCG(I) for appropriate phase of clinical trials.

The department continues to receive applications from institutions working with GMOs for constitution of Institutional Biosafety Committees (IBSCs). Twenty seven (27) new IBSCs have been constituted at various public-funded institutions, universities, private R&D institutions and industries involved in rDNA research. After due diligence to the comments received from government/ private institutions and stakeholders the revised formats for intimating/ requesting IBSC/ RCGM for import/ export/ exchange GMOs/ LMOs and product thereof, and to conduct pre-clinical toxicity studies of recombinant products, biosafety research trials on GE crops under confined conditions and to carry out research and development. In order to strengthen the Indian Biosafety Regulatory System, several consultative meetings with various stakeholders were held. Biology

Documents on Cotton, Okra, Maize and Rice with basic and useful information were developed for the benefit of the applicants conducting Biosafety research trials under contained/confined conditions. Regulatory guidelines for recombinant bio-therapeutic products, formulated on “Similar Biologics”, are under evaluation by other national regulatory bodies for harmonization and implementation. Based on the RCGM recommendations, four sub-committees have been constituted by the RCGM to formulate/revise (1) the present set of guidelines available for conduct and monitoring of confined field trials along with devising new crop specific guidelines; (2) preparation of environmental risk assessment (ERA) guidelines for ERA of genetically engineered crops; (3) Biosafety guidelines to conduct and monitor Confined Research Trials (CRTs) on genetically engineered (GE) Insects; and (4) Biosafety guidelines to conduct and monitor Confined Research Trials (CRTs) on genetically engineered (GE) trees.

As the knowledge in the modern biotechnology is ever expanding, efforts are being made to update with the latest information and also modifications, amendments etc. in the guidelines from time to time for the stakeholders through two dedicated dynamic & interactive web sites on “Biosafety” (<http://dbtbiosafety.nic.in>)

and “Indian GMO Research Information System (IGMORIS)” (<http://igmoris.nic.in>). These websites also facilitate tracking of regulatory clearances on applications to RCGM and e-monitoring of IBSCs on personalized web features. Based on the advancements in the field of agriculture & pharmaceutical areas on GMOs/ rDNA research globally, necessary improvements are being incorporated in the Biosafety regulatory system in the country.

The Industrial growth around the world is steered by technological innovation through research & development. To promote the R&D activities in Biotechnology, 18 private research institutions have been recommended to Department of Scientific and Industrial Research for recognition of their In-house Research & Development Units. Products and services of biotechnology origin were also promoted by communicating department’s view on fixation of standard input/ output norms (SION) for 12 export products; and no objection certificates (NOC) for 14 cases for export/ import of biotechnology products to Directorate General of Foreign Trade (DGFT). Comments/ suggestions have also been provided to various ministries/ departments for commercial release of biotech products, compulsory licensing, foreign direct investment, international commerce and other relevant issues.

Table-6.1: Genetically Engineered crops approved for conduct of confined field trials of BRL-1 by the private/public organizations and seed companies during 2011

S. No.	GE Crop	Institute/ Industry	Transgene/ s
1	Cotton	<ul style="list-style-type: none"> • Maharashtra Hybrid Seeds Co. Ltd., Mumbai • JK Agri Genetics Ltd, Hyderabad • <i>Bayer Biosciences Pvt. Ltd., Gurgaon</i> 	<i>cp4epsps</i> <i>cry1Ac & cry1Ec</i> <i>2mepsps</i>
2	Corn	<ul style="list-style-type: none"> • Pioneer Overseas Corporation, Hyderabad • Syngenta Biosciences Pvt. Ltd., Pune (Bt11 x GA21 event) 	<i>cry1F, cp4epsps & PAT</i> <i>cry1Ab & 2mepsps</i>
3	Mustard	<ul style="list-style-type: none"> • Centre for Genetic Manipulation of Crop Plants (CGMCP), University of Delhi South Campus, New Delhi • National Research Centre on Plant Biotechnology (NRCPB), New Delhi 	<i>bar, barnase and barstar</i> <i>Osmotin</i>
4	Sorghum	<ul style="list-style-type: none"> • Directorate of Sorghum Research, Hyderabad 	<i>cry1B (NRCSCRY 1B, event-19)</i>

Table-6.2: List of rDNA products (Healthcare) approved for Pre-Clinical Toxicity studies during 2011

S.No.	Products	Institute/Industry
1.	<ul style="list-style-type: none"> Pegylated Recombinant Human Granulocyte Colony Stimulating Factor (PEG-rh-GCSF) Recombinant Human Interferon alpha 2a (rh-IFNα-2a) 	Bio Genomics Ltd, Mumbai
2.	<ul style="list-style-type: none"> Pegylated Recombinant Human Interferon alpha 2a (Peg-rh-IFN-2a) 	Avesthagen Ltd., Bangalore
3.	<ul style="list-style-type: none"> Recombinant Human Insulin Analog (Insulin Aspart; B28Asp-Insulin) Recombinant Human Insulin Analog (Insulin Glargine; A21Gly, B31Arg-B32Arg-Insulin) Tenecteplase: Recombinant Fibrin-Specific Plasminogen Activator 	Cadila Pharmaceuticals Ltd., Ahmedabad
4.	<ul style="list-style-type: none"> Trivalent Seasonal Influenza VLP Vaccine Pegylated Recombinant Human Granulocyte Colony Stimulating Factor (Peg-rh-GCSF) 	Virchow Biotech Private Ltd., Hyderabad
5.	<ul style="list-style-type: none"> Rabies G VLP vaccine 	Sudershan Biotech Ltd., Hyderabad
6.	<ul style="list-style-type: none"> Recombinant Human Granulocyte Colony Stimulating Factor (rh-GCSF) 	Shantha Biotechnics Ltd, Bangalore
7.	<ul style="list-style-type: none"> Recombinant Interferon beta-1b (rh-IFNβ-1b) Recombinant HPV Vaccine 	Intas Biopharmaceuticals Ltd., Ahmedabad
8.	<ul style="list-style-type: none"> Etanercept: TNFα Receptor-Fc fusion protein 	Lupin Ltd., Pune
9.	<ul style="list-style-type: none"> Bevacizumab: Recombinant Humanized Anti-VEGF Monoclonal Antibody 	FDC Ltd., Mumbai
10.	<ul style="list-style-type: none"> Etanercept: Recombinant TNFα Receptor-Fc fusion protein 	Gland Pharma Limited, Hyderabad
11.	<ul style="list-style-type: none"> Filgrastim: Recombinant Human Granulocyte Colony Stimulating Factor (rh-GCSF) 	Inbiopro Solutions Pvt. Ltd., Bangalore
12.	<ul style="list-style-type: none"> Teriparatide: Recombinant Human Parathyroid Hormone (1-34) (rh-PTH:1-34) 	Symmetrix Biotech Pvt. Ltd., Chandigarh
13.	<ul style="list-style-type: none"> Teriparatide: Recombinant Human Parathyroid Hormone (1-34) (rh-PTH:1-34) Recombinant Streptokinase (SK) Recombinant Clot Specific Streptokinase (CSSK) 	Reliance Life Sciences Pvt. Ltd., Mumbai
14.	<ul style="list-style-type: none"> Darbepoetin alpha 	Serum Institute of India Ltd., Pune
15.	<ul style="list-style-type: none"> Infliximab: Recombinant Chimeric Anti-TNFα Monoclonal Antibody 	Bharat Biotech International Ltd., Hyderabad
16.	<ul style="list-style-type: none"> Pneumococcal Conjugate Vaccine Polysialylated Erythropoietin 	Cadila Healthcare Ltd., Ahmedabad

S.No.	Products	Institute/Industry
1.	• Darbepoetin alfa	Hetero Drugs Ltd., Hyderabad
2.	• H1N1-09 Influenza VLP Vaccine	Cadila Pharmaceuticals Ltd., Ahmedabad
3.	• Recombinant Enfuvirtide	
	• Rituximab: Recombinant Chimeric Anti-CD20 Monoclonal Antibody · Pegylated Erythropoietin	Virchow Biotech Private Ltd., Hyderabad
4.	• Filgrastim: Recombinant Human Granulocyte Colony Stimulating Factor (rh-GCSF)	Intas Biopharmaceuticals Ltd., Ahmedabad
5.	• Pegylated Recombinant Human Granulocyte Colony Stimulating Factor (PEG-rh-GCSF) · Teriparatide: Recombinant Human Parathyroid Hormone (1-34) (rh-PTH:1-34)	USV Ltd., Mumbai
6.	• Recombinant Live <i>Vibrio cholerae</i> VA 1.4 Vaccine	Lupin Ltd., Pune
7.	• Clot Specific Streptokinase	
8.	• Peg-Filgrastim: Pegylated Recombinant Human Granulocyte Colony Stimulating Factor (PEG-rh-GCSF) · Trastuzumab: Recombinant Humanized Anti-HER2 Monoclonal Antibody Bevacizumab: Recombinant Humanized Anti-VEGF Monoclonal Antibody · Infliximab: Recombinant Chimeric Anti-TNF α Monoclonal Antibody · Darbepoetin alfa	National Institute of Cholera & Enteric Diseases (NICED), Kolkata
9.	• Rituximab: Recombinant Chimeric Anti-CD20 Monoclonal Antibody	Symmetrix Biotech Pvt. Ltd., Chandigarh
10.	• Pegylated Recombinant Human Granulocyte Colony Stimulating Factor (PEG-rh-GCSF) · Trastuzumab: Recombinant Humanized Anti-HER2 Monoclonal Antibody	Reliance Life Sciences Pvt. Ltd., Mumbai
11.		

Patent Facilitation Cell

The main objective of Biotechnology Patent Facilitating Committee (BPFC) of the Department of Biotechnology (DBT) is creation of awareness and understanding relating to intellectual property rights (IPR) among students, scientists and faculty of colleges, universities and research institutes through workshops, seminars and conferences. BPFC also assists the investigators in patent filing in IPO, USPTO and other countries. All patent applications on inventions pertaining to Life Sciences and Biotechnology received in the Department are subjected to a rigorous scrutiny. Based on merit, department provides administrative and financial support for patent filing in India and other countries. The patent filing is done through National Research Development Corporation (NRDC), New Delhi. BPFC also plays an important role in transfer of technology to industry and its commercialization.

During the period, 17 patent applications were process for filing with IPO, USPTO and in other countries through NRDC. Seven technologies are under process for transfer

to industry and further commercialization. The following six patents have been granted during the year 2011-12

1. Oligonucleotides for detection of Leishmaniasis and methods thereof (Patent no. 246347/India)
2. Diagnostic kit for detection of Pulmonary and extra pulmonary Tuberculosis (Patent no. 7888037B2/US)
3. Novel Polymer for solid phase peptide synthesis and process for preparation thereof (Patent no. 248550/India)
4. An Oligonucleotide primer pair for detection of *Mycobacterium tuberculosis* using the primer (Patent no. 248630/India)
5. Process for producing a Biopesticide composition containing *Trichoderma harzanium* and *Pseudomonas fluoresces* (Patent no. 7923005B2/US)
6. Process for the preparation of Herbal Extract from the Fern *Cheilanthes farinose* effective against liver diseases (Patent no. 250038/India)

BIOTECHNOLOGY INFORMATION SYSTEM NETWORK

Biology in the 21st century is being transformed from a purely lab-based science to an information science as well. Over the past few decades, major advances in the field of molecular biology, coupled with advances in genomic technologies, have led to an explosive growth in the biological information generated by the scientific community. The sequencing and mapping of Human Genome and hundreds of other genomes has, in turn, led to an absolute requirement for computerized databases to store, organize, and index the data and for specialized tools to view and analyze the data.

The Bioinformatics is attaining greater significance in the life sciences research and industry and hitherto unexplored areas of biology. Bioinformatics, computational and systems biology are data driven and algorithm intensive research areas are becoming important. In the field of bioinformatics, the life sciences sector is now focusing on analysis and interpreting voluminous data generated through biological research. Biological research has become more and more data intensive and requires advanced Bioinformatics

infrastructure, databases and human resource who could transform the data into meaningful information, understanding and product development. The BTISnet of DBT is promoting these activities efficiently. Major such activities are discussed herewith.

BTISnet in a Nutshell

BTISnet a potential scientific network in the country comprises of more than 165 institutions. The network embraces state of art infrastructure, human resource development and exhibited capability in carrying out intensive research and development activities in bioinformatics and computational biology. Based on the outcomes of BTISnet a compendium on “Research publications in Bioinformatics and computational biology from India” was released on 3rd February, 2012 listing more than 3000 peer reviewed research publications in these areas. Centers of BTISnet were networked through high speed leased line connectivity earlier and now some of them are being networked through National Knowledge Commission (NKN) network. Skilled human resources

& 4th February 2012 at Shri Mata Vaishno Devi University, Jammu with a focal theme of “Bioinformatics in 21st Century- Looking ahead”. Prior to this a National Symposium on “Bioinformatics: Challenges in the Post-Genomic era” was organized by the University of Jammu on 2nd February 2012. Three important programs of DBT on DBT’s e-Library Consortium (DeLCON), Conference, Travel, Exhibition and Popular Lectures (CTEP) and the Innovative Young Biotechnologist Award (IYBA) are being very effectively coordinated by the Apex BTIC in DBT. The location of the centres is depicted in the Map below (Figure 7.1).



Fig. 7.1: Map showing the locations of BTISnet Centres

Centres of Excellence (COE) in Bioinformatics

Six CoEs in Bioinformatics and Computational Biology have been established as part of BTISnet. These Centres are well equipped with State of Art Bioinformatics infrastructure to support research within the Institute as well as neighbouring institutions. The CoE at Bose Institute, Kolkata is specialising in the areas like genome analysis, regulatory RNA stem cells and genomics and structural bioinformatics. It provides projects to students undergoing Post Graduate courses from your large number of institutions and universities. In 2011, 16 important research papers have been published by the Centre. The CoE at IISc Bangalore has shown a paradigm shift in the focus of the centres activities which is now directed towards strengthening integrated research programmes in several areas of Bioinformatics with a long term goal of developing computational modules of Biological macro-molecules and cellular processes at different levels of abstraction to aid new hypothesis generation, new ways of research in Biology and in generating applications, opportunities in drug and vaccine discoveries. The Centre hosts a major mirror server for structural classification of protein (SCOP) structures.

The Centre also has Cambridge structural database (CSD) which contains more than 586,977 small module structures. 68 Project Assistant, 23 Project trainees and 98 summer trainees have been trained both at CoE and the interactive Graphic Facility. 23 high impact publications have been published during this year.

The CoE at JNU, New Delhi is a part of the School of Computational and Integrative Sciences, with a major objective of development of human resource through teaching and research in the frontier area of computational biology, bioinformatics and systems biology. The Centre is also working on Mycobacterium tuberculosis, through TB Consortium project supported by DBT and the Centre is also engaged in Leishmania and *Plasmodium falciparum*. The Centre under the CoE Umbrella conducts M. Tech course in Bioinformatics, Computational and Systems Biology. In addition, the Centre also conducts BINC Examination since 2010-2011 onwards. 27 Peer reviewed research publications have been published by this Centre during the reporting period. The CoE at Madurai Kamaraj University, Madurai is specialising in the areas like structural Bioinformatics, proteomics data mining and computer aided drug design. Towards manpower development the Centre runs network M. Sc. Computational Biology course along with Anna University, Chennai

and Pondicherry University, Pondicherry. The Centre is having collaborative research with international and national institutions in the field of Bioinformatics such as Wiseman Institute, Israel, University of Utah, USA, Aravind Eye Hospital, Madurai, NCBS, Bangalore and AIIMS, New Delhi. They conduct research with them in the areas like *E. Coli*, fungal kinetics, classification of proteins, *M. tuberculosis* and *in-silico* drug design. More than 20 papers have been published by the Centre during this year.

The Centre at University of Pune, Pune conducts M. Sc. in Bioinformatics and before

2010-11 this Centre was organizing the BINC examination. The Centre has developed 3 major databases namely viral protein structural database, antigen antibody genomics and viral genome resources. 12 important papers have been published by the Centre during this period. The CoE namely Super- computing Facility for Bioinformatics (SCFBio) at IIT Delhi provides super-computing facility for the institute, researchers and scholars. Centres are also utilising its resources both hardware and software packages developed by the Centre. The website showing software for predicting DNA-Drug interaction strength has been shown as Figure 7.2.

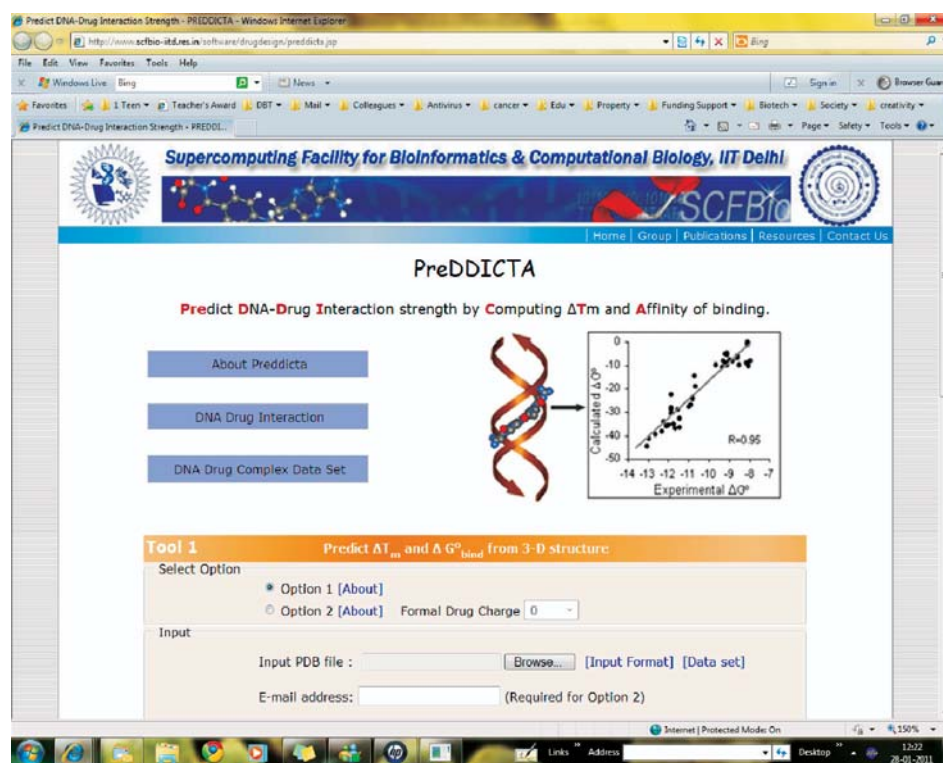


Fig. 7.2: Software for predicting DNA-Drug interaction strength

Bioinformatics Infrastructure Facilities (BIF) For Biology Teaching through Bioinformatics (BTBI)

To promote the biology & biotechnology teaching through bioinformatics, a scheme was launched recently namely Bioinformatics Infrastructure Facility (BIF) to promote innovations in the area of Biology & Biotechnology among the Institutions/ Universities/ Colleges all over the Country. The scheme is designed to expose teachers, scientists and students to the real-world of science and the use of bioinformatics in solving hard core biological problems. Several sites provide free access to biological information resources to promote advanced biology and develop human resource to undertake challenging research in the field of modern biology. The centre can use the lecture materials, video clippings, demonstrations, tutorials and online facilities to cater the need of present generation in modern teaching and innovation. Ninety nine educational institutions have so far been supported under this scheme and some more are in pipeline.

Sub-Distributed Information Centre

Fifty centres of this category are as part of BTISnet. These Centres are located at

various Institutions/Universities and are working along with specialized areas of Bioinformatics. At one point of time these Centres were considered as user Centres of Bioinformatics and over the period of time the Sub-DICs also have shown their capabilities in training the people as well as development of information resources in the form of Databases. Many Centres of this level are doing good bioinformatics R&D and have published number of Bioinformatics peer reviewed Research Publications.

North Eastern Bioinformatics Network (NEBInet)

A separate NEBInet has been established by including 27 Bioinformatics centers in the North Eastern region of India as a part of BTISnet. These Centres are mainly located at various universities, colleges and institutions to promote modern scientific research communication among the scientific community, sharing of information and help in initiating collaborative R&D activities in various fields of life. Being a North Eastern States Centre's, these centers are given special emphasis for an overall development in the Country and are linked with all other BTISnet Centre. During the current year two centers were established in the North Eastern Region.

Human Resource Development in Bioinformatics, Computational and Systems Biology

Bioinformatics is an emerging interdisciplinary area of biotechnology and encompasses systematic development and application of IT solutions to handle biological research problems. Areas such as proteomics, genomics, combinatorial chemistry, statistics, nanotechnology, spectroscopy and structural and computational biology will have increasing applications of Bioinformatics in days to come. To handle all these biological research problems, it requires highly trained manpower to deal molecular biology and application of software tools. The department had accorded this area high priority and has introduced several innovative educational activities to meet the present requirements including several long-term and short term educational programs to address this gap. The details are as follows.

M. Sc. Network Program, M.Tech & Advanced P.G. Diploma Courses in Bioinformatics

The objective of this network programme is to share the expertise of teachers as well as the resources which are created by the BTISnet Centres. The MKU, Madurai,

Pondicherry University, Pondicherry and Anna University, Chennai initiated a Network programme on higher education in “M.Sc. Computational Biology” on consortium basis. These places are utilizing the resources through video conferencing and virtual class room approaches. The program envisages creating of a strong computational and experimental basis to bioinformatics education at the post graduate level. The other universities i.e. i) JNU, New Delhi ii) Pune University, Pune and iii) Calcutta University, Kolkatta are continuing M.Tech., M.Sc. and Post Graduate diploma courses in bioinformatics, respectively. This year more than 70 students graduated from these programs.

Ph.D. Program in Bioinformatics

The COEs of BTISnet including the super computing facility at IIT, New Delhi are running Ph.D. programs in Bioinformatics to meet the huge requirement for high end human resource in Bi3oinformatics & Computational Biology and training.

Short Term Training Programs

Basic understanding and hands on experience in the area of Bioinformatics is provided to the researchers and students, by each of the BTISnet Centre by conducting one or more short term training programmes

each year. A schedule of the training programmes conducted by BTISNet Centres is published in the form of annual training calendar each year by the Department. The BTISnet centres organized more than 100 short-term training during the year 2011-12 so far.

Bioinformatics National Certification Examination (BINC)

The BINC examination was introduced in 2005 by the Department of Biotechnology (DBT), Government of India to certify professionals in the area of Bioinformatics as the subject has emerged as an independent discipline over the years and is assuming an increasingly important role in the Life Sciences research in the post-genomic era. The University of Pune has coordinated the BINC examination on behalf of DBT during 2005-2010. The BINC National Coordination committee is the driving force in setting and maintaining high standards of the BINC examination. The examination is conducted at eight centers and has gained in popularity over the years as evidenced by the number of candidates that appeared for the examination and the number of candidates that qualified for certification. (<http://binc.scisjnu.ernet.in/>). Any science graduate with or without formal training in Bioinformatics can appear for this examination. However, to be eligible

for BINC JRF fellowship and register for PhD in Bioinformatics & computational biology, the candidates must possess a Master's degree in Science or Technology or Medicine. The exam employs a three-tier system including an objective, subjective and practical examination. All the candidates who register for the BINC examination appear for Paper I. Those who secure 40% marks in paper I are eligible to appear for Paper II, which is subjective type and Paper III, which is hands-on practical examination.

All successful candidates are awarded with certificates of proficiency in Bioinformatics, a cash awards of Rs. 10,000 to each of the top ten candidates and research fellowships (DBT-BINC-JRF) to carry out research leading to Ph.D. in the area of Bioinformatics in any of the recognized Indian Universities/Institutes. The fellowship is at par with NET, GATE, BETnational Exams. JNU, New Delhi is conducting the BINC exam from 2011 onwards. So far, 85 candidates have qualified the BINC and out of them 15 are availing the fellowship.

R&D in Bioinformatics and Computational Biology

During the year, the department has received more than 50 R&D projects in the area of bioinformatics and sanctioned new 12 R&D projects. Besides that the

department also continued support to eight ongoing projects on Bioinformatics and Cell engineering generated through Indo-Japan Collaboration and 117 new projects through the twining program for North Eastern States. The projects were supported in the area of Molecular Dynamics Studies of the Homology Model of CYP1A1, Structure Based Drug Design and Virtual Screening of Potential Ligands that Modulates the Biological Function of CYP1A1, Development of Computational Mosquito borne viral data and potential antiviral drugs by isolation of arboviruses from female mosquitoes and in silico screening for immunogenic membrane protein and modeling of suitable antivirals including *in vitro* confirmation, Study of some important signalling and metabolic pathways in T-cell and glioma, role of protein complexes and protein protein interaction network in eukaryotic protein evolution, understanding Systems Biology of a Rhizobacterium, *Azospirillum brasilense* by *in-silico* and *in-vitro* study of the cascades and Networks of Sigma Factors, Anti – Anti Sigma Factors, development of internet computing engines and knowledgebase for the analysis of protein sequences and structures, development of new phasing tool for faster macromolecular structure determination, Discovery, annotation, validation and

characterization of SNPs in Wheat (*Triticum aestivum* L.) and haplotype structure determination using Next-Generation Sequencing Data, Drug Target Identification in Infectious Disease through Molecular Simulation and Biochemical Network Modeling and Online tool development for extraction of diseased proteins and pattern database creation.

Consortium Projects on Bioinformatics

Two major consortium projects viz. (i) TB-bioinformatics and (ii) Rice bioinformatics are running smoothly. TB Bioinformatics II phase has been sanctioned this year. In TB-bioinformatics seven major institutions are partners, and, in rice bioinformatics eight institutions namely NBPGRI, New Delhi, NRCPB (IARI), New Delhi, CRRI, Cuttack, IGKV, Raipur, DRR, Hyderabad, CSSRI, Karnal, IAS, Varanasi and UDSC, New Delhi are the partners. Rice Bioinformatics project has entered in its second year of implementation and has shown good progress. A comprehensive database on these two areas will be available at the end of these projects. A new consortium project on Mango is being initiated this year with 10 participating institutions from all over India, who are working in the area of Mango.

DBT's e-Library Consortium (DeLCON)

DBT e-Library Consortium (DeLCON) launched in January 2009 is running successfully. More than 30 institutes are part of the consortium. The institution as part of the DeLCON are able to access more than 900 important journals. This has expedited the pace of research in the country and supported for the access of scientific literature at the click of a mouse. The steering committee of the consortium meets at regular intervals and reviews the progress of the use of various journals and to assess for addition or deletion of the journals from the list of subscribed journals. The portal of the consortium can be accessed through www.delcon.gov.in.

BTISnet website

A lot of information is required to be disseminated to the bioinformatics Centre of the BTISnet. The BTISnet website with URL <http://www.btisnet.gov.in> provides a central resource to all the bioinformatics centres in respect of the work done by each one of them in the area of bioinformatics. Through this site, the BTIC provides all information such as budget release status of submission of accounts and progress report by the BTISnet Centres. The site provides a list of open access journals, details of the fellowships provided through

the bioinformatics division like BINC, studentship and traineeship, access to online lecture portals and their links, announcements of the national bioinformatics coordinators meetings and its proceedings, bioinformatics publications from India and the bioinformatics resources like software and databases. Website has been reengineered and was launched on 3rd February 2012 during the XXIII BTISnet Coordinators Meeting at SMVDU, Katra, Jammu.

Coordinator's Meeting of Biotechnology Information System Network (BTISnet) held at Jammu on 2nd to 4th February, 2012.

BTISnet is one of the largest network comprising 168 Centres including Centre of Excellence (CoE), Distributed Information Centre (DIC), Sub-Distributed Information Centre (Sub-DIC) and Bioinformatics Infrastructure Facility (BIFs). The progress of these Centres was continuously reviewed annually and in this series the 23rd Coordinator's Meeting was organised at Shri Mata Vaishno Devi University (SMVDU), Katra on 3rd - 4th February, 2012. Prior to this meeting a National Symposium on "Bioinformatics: Challenges in the post -genomic era" was organized on 2nd February, 2012 at University of Jammu.

Fourth North Eastern Bioinformatics Network (NEBInet) Coordinator's Meeting

Under the Special drive to strengthen the North Eastern States of the Country, a Bioinformatics network was established as "NEBInet" comprising of Centers at various Colleges, Universities and Research Institutions under the Biotechnology Information System Network (BTISnet) programme of DBT. This Network is with connectivity of 27 Centres in all the 8 States of NE region including Sikkim to promote teaching, research and innovation through Biotechnology and Bioinformatics (BTBI) programme. During this year the Sub-Distributed Information Centre (Sub-DIC) at NEHU, Shillong was upgraded to Distributed Information Centre (DIC). The network Centres are being reviewed every year through the Coordinators Meeting of NEBInet. In this series, the 4th NEBInet Coordinator's Meeting was held at North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli, Arunachal Pradesh on 10th -11th November 2011.

Bioinformatics Training Calender 2011-2012

Short term Trainings have become an integral part of the BTISnet over last decade. Constituent bioinformatics centres of the

BTISnet are regularly organizing short term training programmes in new and upcoming areas of bioinformatics to train the researchers and scientists in the latest developments in the fast developing area of Bioinformatics for the innovations in Biology and Biotechnology and to explore the hitherto unexplored domains. Training calendar of these trainings for the year 2011-2012 was published (Figure 7.3). A total of 107 training programs have been covered

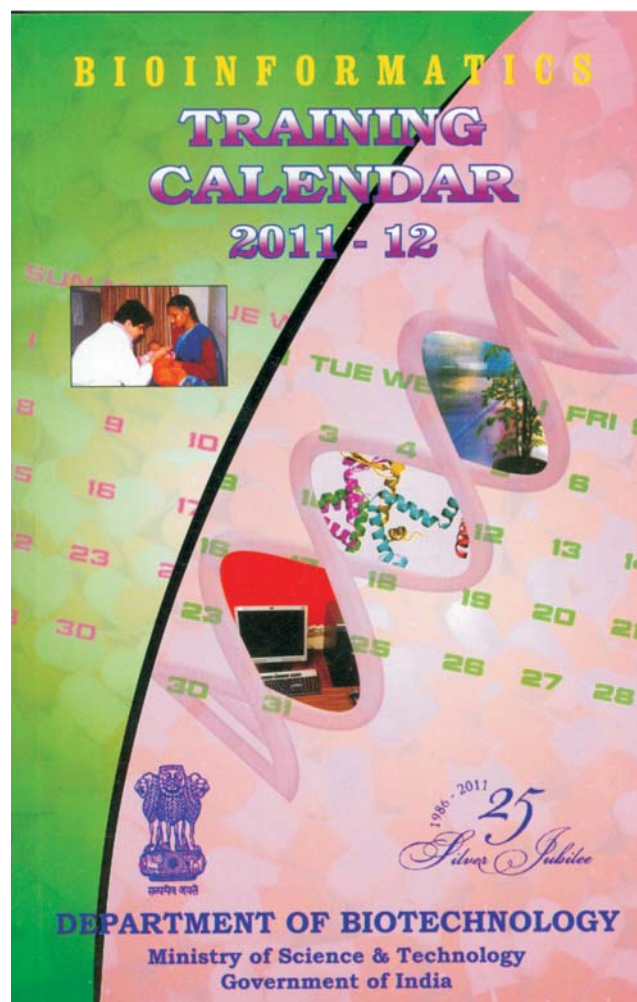


Fig. 7.3: Training calendar of these trainings for the year 2011-2012

in this publication in nine different areas of bioinformatics. These specialized areas include Knowledge Discovery from Data, computational and structural bioinformatics, network pathways and systems biology, Genome and Proteome Analysis, bioinformatics with respect to medical sciences, agricultural and plant sciences, environment and biodiversity, general

bioinformatics training and teachers trainings in bioinformatics. Scientists are taking benefit from these trainings to make valuable contributions to their areas of research. The calendar has been distributed to the Bioinformatics centres and institutions countrywide. The training calendar is also available through the website of DBT <http://www.btisnet.gov.in>.



BIOTECHNOLOGY PARKS AND INCUBATORS

Department established biotech parks to facilitate product advancement and innovation through the development of biotechnology industrial cluster and to produce biotechnologists and entrepreneurs having strong foundation in research and innovation. With large number of multinational and bio-pharma companies initiating their R&D and manufacturing operations in India, the demand of biotech incubators has increased. Both Central and State Governments are making efforts to promote biotechnology activities in the country by setting up biotechnology parks, incubators as well as pilot projects through public private partnership. DBT has supported the following biotechnology parks and incubation centers located in different states.

Biotechnology Parks and Incubation Centres

Biotechnology Park, Lucknow

Biotech Park, Lucknow is fully operational for upcoming entrepreneurs to set up their R&D units in Park by providing incubator facilities for solvent extraction, aqueous

distillation, plant tissue culture and bio-fertilizers. The Park is a model of active collaboration between industries, research institutions and academia and has motivated local scientists and entrepreneurs to venture into Biotechnology and focuses on Agri-and Pharma-biotechnology and issues related to technology development. It has Quality Management System Certificate from Norsk Akkreditering of Norway. NS-EN ISO 9001:2008/ISO 9001:2008. The Park significantly contributed in making Uttar Pradesh a successful tissue culture hub for banana by bringing down the cost of plants by 33% and providing good quality plants. Large number of farmers in the state are growing G-9 tissue culture banana. The Tissue Culture facility of the Biotech Park has been recognized under National Certification System of Tissue Culture raised Plants (NCS- TCP) by the accreditation panel of DBT. During the financial year Biotech Park supplied (approx) 6.00 lacs tissue culture raised G-naine variety banana plants produced in tissue culture laboratory to the cultivators under State/ National Horticulture Mission Programmes. The state Government of Uttar Pradesh has notified the Biotech Park as nodal agency along with

the other agencies for supply of the biofertilizer products in the state government departments.



Fig.8.1: Tissue Culture Facility setup at Biotech Park, Lucknow

The park has made substantial contributions to the National Mission on Biofuels by developing four high yielding and oil rich varieties of *Jatropha curcas* and providing technical know-how for development of good nurseries and quality planting material and is providing consultation to the companies in the field of bio-fuel and necessary technical guidance, planting material and monitoring of the plants. BTPL has supplied approximately 40 lacs *Jatropha* plants in the state of U.P. for plantation.

An important contribution of the Park has been towards building capacities of the much needed human resource development. The park houses 18 biotech companies. A

total of 520 graduates and postgraduates and Ph.D. scholars received short term & long term training in different areas of biotechnology. The Biotech Park's incubator II building has become functional and space has been leased out to setup their R&D laboratories. Besides the wet lab laboratory space, the incubator II has multipurpose meeting rooms/conference hall to accommodate 300-325 persons, offices and other related facilities.

Biotechnology Park, Bangalore (Karnataka)

DBT supported for establishing an incubation centre and Common Instrumentation Facility at Biotechnology Park at Bangalore. The cost of the project was Rs.32.26 crores and the DBT's share was Rs.14.45 crores, out of which Rs.11.13 crores has been released so far. Karnataka Biotechnology & Information Technology Services, the implementing agency for the development of the park is in process of developing the Incubation Centre.

Biotechnology Park, Kerala

The proposal for setting up of a Biotechnology Incubator at Kerala Biotechnology Park was sanctioned in March 2005 at a total cost of Rs.23.18 crore. The share of DBT is Rs.11.00 crore and the rest is to be contributed by the State

Government. An amount of Rs.2.5 crore has been released so far by the DBT. The rest amount is being released by the Department during the current financial year. The civil works of the Biotechnology Incubation Centre have been completed by the state government at a cost of Rs.5.60 crore. Various utilities have been created in the building, which has a built up area of 50,000 sq ft with 10 modular laboratory spaces of approx 1000 sq ft each and the office spaces. Besides, there is a provision for setting up of a Central Instrumentation Facility, Medicinal Plant Extraction Facility, Micro Propagation Facility and Fermentation Facility.

Guwahati Biotech Park Technology Incubation Centre (GBPIC)

The project of setting up of Guwahati Biotech Park Technology Incubation Centre has been sanctioned by the DBT at a total cost of Rs. 27.99 crore for a period of three years. An amount of Rs. 24.379 crore has been released. Renovation work undertaken to set up the interim incubation centre for the building provided by IIT, Guwahati. The progress of the park is regularly monitored by GBPIC Management Committee and Technical Advisory Committee. Land for setting up of the Park for constructing of the permanent campus for Incubation Centre has been identified.



INTERNATIONAL COLLABORATION

International Cooperation is an instrument to address global challenges of food, health, nutrition and climate change. Programmes pursued aim at bridging technology gap, exchange training of scientific manpower and leads way for the development of cost effective innovative technologies. DBT has entered into bi/multi-lateral strategic alliance with a focus on global challenges. Vision behind these alliances is to promote scientific excellence & capacity building, triggering of innovation environment amongst industry and academia alike. In current year (2011-2012), six joint calls for proposals with Canada (ISTP), Denmark, Finland, EU, New INDIGO and US were announced. The calls primarily focused on fostering closer ties through bilateral industry-academia relationships. Department in its pursuit for innovation, capacity building and enterprise development has successful ongoing programmes. These include the DBT-Wellcome Trust (WT) fellowship programme on biomedical research at post-doctoral level; the Khorana Scholars Program with University of Wisconsin (UW) for Indian students pursuing B.Tech, M. Tech or M.Sc degrees to spend 10-12 weeks in research

lab in UW. Department in partnership with ABLE have successfully conducted Biotechnology Entrepreneurship Student Teams (BEST) programme for development of enterprise amongst young doctoral and training them in techno-managerial issues. The Department has established successful collaborations with strategic partners like Australia, Canada, Denmark, Finland, Japan, Norway, Sweden, Switzerland, UK, EU and USA; with increasing financial commitment from the collaborating countries for these collaborations.

Indo-Canada

A joint call for proposal has been announced by DBT and ISTP, Canada in all areas of biotechnology including Life Sciences and medical devices. Significant achievements of some of the ongoing projects are detailed below:

- SoftTeam, India in collaboration with AUG, Ontario and clinical partners SickKids, CMC and KMH, have successfully developed software components which automatically acquire, store, process images from PET

/ MRI modalities and automatically detect brain tumour using these images. Software can build atlas of brain anatomy - registration and fusion of healthy MRI data sets and fusion of detection results from PET-MR images.

- At SJRI in collaboration with University of Toronto, the system requirements for the platform that can function on laptop, store data of the blood samples from patients in remote areas and transmit it to laboratories, have been developed e.g. Pilot studies have been carried out successfully from remote location Barshi (Maharashtra) having a limited connectivity and transmitted to a laboratory in Mumbai, where it was received and stored. Software is now being developed for multi-lingual questionnaire, tracking of user timings etc.
- In another project partnering ICGEB, BITS, LifeCare Innovations and University Health Network, Toronto, 15 anti-malarial analogues have been synthesized, characterized and screened for falcipain-2 inhibition assay. The lead compound supplied by University Health Network, Toronto, Canada called KP15 has been developed as nano-formulation using an US-FDA approved synthetic polymer PLG (Poly-lactide-co-

glycolide). The thermo stable formulation with optimal size, highest encapsulation efficiency is being considered for commercialization.

Indo-Denmark

DBT and the Danish Council for Strategic Research, Ministry of Science & Technology and Innovation, Denmark are supporting proposal in the broad area of life science:

- This year a project on Genetics and Systems Biology of Childhood Obesity in India and Denmark (BIOCHILD) has been supported.
- In the ongoing project implemented at IIT Kharagpur and IARI along with Technical University of Denmark, promising strains of cyanobacteria have been identified for production of biochemicals, pigments, phenolics, biohydrogen production and increased nitrogen fixation ability for use as biofertilizer for rice, wheat cropping systems in India. In addition, IIT, Kharagpur is developing technology for increased algal biomass production.
- Under another ongoing project at SGPGIMS Lucknow, along with University of Southern Denmark, the group has established the Small Animal

Imaging Facility (SAIF) with installation of NanoSPECT-CT. The goal of this facility is to provide state-of-the-art small animal imaging services to Researchers/ Scientists of SGPGIMS and other Institutes of the country and to evolve this facility into a National Training Centre. This new imaging technique has been used for quantifying variable left ventricular remodelling after stem cell therapy in two rat models of cardiac disease viz. ischemia/reperfusion (I/R) and global heart failure models.

Indo-Finland

Department of Biotechnology has a strong ongoing collaboration with Finland through two of Finland's funding agencies – Academy of Finland (AoF) and TEKES. The AoF is the major Government funding agency for basic research while TEKES is the funding agency for technology innovation and industry collaboration.

Three proposals under the area of food biotechnology are being funded under the DBT-AoF cooperation.

- In a project at TERI, Delhi, GBPUAT Pantnagar and MTT Agrifood Finland, Rhizocompost from agriculture byproducts (made from de-oiled Jatropha seed cake, Rice straw and Cow

dung) and enriched with arbuscularmycorrhizal fungi (AMF) and 6 other microbes has been developed. In greenhouse experiments this formulation was found to be growth promontory in tomato and lentil plants and could also control biotic and abiotic stress.

- In another project at UDSC, Delhi and University of Helsinki, Finland heat shock factors (Hsfs) that bind with heat shock elements (HSEs), eventually resulting in transcriptional activation of heat shock (HS) genes have been identified. Transgenic Rice plants overexpressing Hsf genes have shown promising results in mitigating abiotic stresses.
- In the project at NEERI, Nagpur in collaboration with Finnish Environmental Institute, Helsinki herbicide Atrazine mineralizing isolates of microbes have been identified using genomic tools from sugarcane fields. These isolates can be utilized as a consortium for bioaugmentation and bioremediation. The *trzN* gene identified using genomic tools can be used for monitoring degradation of Atrazine. A DBT sponsored Indo-Finland workshop on 'Genomic tools in Bioremediation', Nov 29-30, 2011 was successfully organised at NEERI, Nagpur under the project.

- In a project jointly executed by Indian Institute of Science, Bangalore and University of Oulu, Finland successful structure of a protein annotated as an SCP2 thiolase (STLP1) coded by *Mycobacterium smegmatis* was determined at 2.7Å resolution. Protein belongs to Thiolas family of enzymes that catalyze the Claisen condensation of acyl-CoA molecules in the synthetic direction and the thiolytic cleavage of 3-ketoacyl-CoA molecules in the degradative direction. The protein residues known to be essential for catalysis in thiolases were not found to be conserved suggesting that STLP1 has another, yet to be discovered function.
- The group at Rajiv Gandhi Centre for Biotechnology, Kerala in collaboration with University of Helsinki has identified the presence of deadly pathogen, *Batrachochytrium dendrobatidis* amongst *Indirana* frogs from the Western Ghats. The pathogen is responsible for the world wide depletion of amphibians and is reported in Indian frogs for the first time. In addition they have documented high cryptic diversity of endemic *Indirana* frogs in the Western Ghats. A comprehensive review of taxonomy (including all known synonyms), systematics, morphological and life history characteristics, as well as of the breeding biology of *Indirana* species of Western ghats have been prepared.
- Another project being carried out at ICGEB and VTT Technical Research Centre of Finland aimed at development of safe recombinant forms of allergens and antibodies in plants for diagnostic and therapeutic purposes for Allergen Asp f1 (*Aspergillus fumigatus*) and α -lactoglobulin (BLG) specific IgE antibodies (D1). Stably expressing transgenic tobacco and barley cell cultures, tobacco plants and barley seeds for D1 antibodies have been obtained and a procedure for purifying antibodies from tobacco leaf extracts has been developed.
- Project being implemented at IISER, Pune and at Turku Centre for Biotechnology, Finland envisages establishing patterns in the levels of serum proteins that would be descriptive of increased risk, progression and early onset of T1-Diabeties from patients at various stages of T1D development. The important goal is to help understand the development of T1D, and find novel combinations and biomarkers. Towards this end candidate proteins have been identified in the serum.

Indo-Germany

Under the cooperation in biotechnology between Department of Biotechnology (DBT), Government of India and German Federal Ministry of Education, Science Research and Technology (BMBF) forschungszentrum Julich GMBH (FZJ) a 2+2 programme has been initiated, in which joint projects would be developed with participation of one research institute and one industry from each side. Nine projects are underway and the major outcomes are given below:

- Project being implemented at ICAR, Goa and Justus-Leibig University, Germany has resulted in development of an ELISA based assay using listeriolysin O as an antigen, which is being commercialised for *Listeria monocytogenes* detection. A protocol for real time PCR assay of the pathogen has also been developed. A significant achievement of the project is the establishment of well characterized repository of the strains of *Listeria* isolated from almost 12 states of India.
- Ongoing project at IGIB Delhi and at Abteilung Klinische Chemie-Zentrallabor, Gottingen, Germany aims to develop methodologies for specific and early diagnosis of *Aspergillus fumigatus* caused allergy and desensitization therapies of allergic disorder. Based on immunoproteomic approach twenty new allergenic proteins of *A. fumigatus* have been identified. The panel of newly identified allergens will be useful in designing peptides of diagnostic and therapeutic value.
- The ongoing project at NCL Pune and at University Anhalt, Germany has been successful in integrated carbon recovery using photo-bioreactor grown algal biomass to enrich methane from biogas using polypropylene hollow fiber membranes as contactors, for recovering more than 90% of the CO₂ from biogas using sewage as a sweep liquid in a two stage membrane process. A provisional patent has been filed for the technology.
- Under the project being implemented at GBPUAT, Pantnagar and University of Munster, Germany, 20 highly copper tolerant isolates of fungal antagonist *Trichoderma* were collected from different agro-climatic conditions. Field evaluation of different copper based fungicide compounds and *Trichoderma* against potato have been successfully conducted.
- In a project jointly executed by IISc., Bangalore and Deutsches Krebsfor-

schungszentrum Germany, serum samples from GBMs and healthy controls were analysed for 810 cancer specific markers by antibody microarrays. It was concluded that CRP has potential to serve as an independent prognostic marker for GBM.

- Ongoing project at NIRRH, Mumbai and Max Planck Instt. for Molecular BioMedicine Germany, functional validation of Oct-4 gene presumed to have role in the process of self-renewal of spermatogonial stem cells was validated by knock down of endogenous expression of SSC utilizing lentiviral mediated shRNA approach. Currently; studies are underway to evaluate the effect of Oct-4 knock-down on the expression of genes involved in SSC self-renewal whose functions are under the control of Oct-4.
- In the ongoing project at NIPGR, Delhi and Leibniz Instt. of Plant Genetics and Crop Plant Research Germany, it was concluded that the tolerant cultivars of foxtail millet possess wider array of antioxidant machinery with efficient ascorbate-glutathione pathway to cope with drought-induced oxidative stress. A synonymous single nucleotide polymorphism (SNP) associated with dehydration tolerance was detected in the *SiDREB2*. A set of 147 genomic microsatellite and 98 novel intron length polymorphic markers were developed for eventual use in diversity analysis and breeding programmes.
- The ongoing project being carried out at ICGER, Delhi and Helmholtz Centre for Infection Research Germany is based on the evidence that the dengue virus envelope domain III (EDIII) is a potential vaccine antigen. Successful secretory expression, purification and characterization of monovalent dengue EDIII antigens corresponding to four serotypes of dengue virus has been achieved. Immunogenicity studies demonstrate that all the EDIII recognize anti-EDIII antibodies in a serotype specific manner.
- Ongoing project running at SGPGIMS, Lucknow and Institute of Neuroscience and Medicine, Germany successfully correlates the role of Vitamin B-12 in brain development using modern imaging techniques revealed reduction in the anterior thalamic radiation (ATR) & posterior thalamic radiation (PTR) fibers bundles of patient with vitamin b12 deficiency as compared to controls. Project was successful in correlating development of different regions of brain in relation to cognitive ability of individuals with vitamin B12 deficiency.

- Under the project at ILS Bhubaneswar and Inst. of Medical Microbiology, Immunology and Parasitology (IMMIP), University Clinic at Bonn, Germany a deletion of 23 bp was identified in Toll like receptor 2 in patients suffering from *Bancroftian filariasis*. Toll like receptor 2 plays an important role in human filariasis by recognizing *Wolbachia*, an endosymbiont of filarial parasite and induce inflammatory immune responses.
- The group at University of Mysore and University Hospital of Freiburg Germany has successfully found that angiogenic receptors Flt-1 and Tie-2 are overexpressed in human breast cancer cell lines and in human biopsies from breast cancer patients. Project will pave way for treatment of breast cancer using immunoliposomes.
- In another ongoing project at University of Delhi, South Campus, and University of Heidelberg Germany two (nPAC35 and 75) novel photoactivated adenylate cyclases (PACs) were cloned, purified and characterized for the photo-dynamic kinetic properties. For the first time, bacterial light-gated ion pumping rhodopsin (CvRh) was localized in plasma membrane of eukaryotic algae.
- The ongoing project at CCMB, Hyderabad and Max-Planck- Institute for Infection-Biology Germany have successfully validated the hypothesis that the small GTPase Rap1A, plays an important role in macrophage adhesion process and phagocytosis of *Mtb*, hence in tuberculosis disease establishment and progression.
- In the collaborative project between GNDU, Amritsar and Humboldt University Germany genes responsible for different type of retinal dystrophy has been successfully identified by whole genome linkage analysis in an autosomal dominant retinitis pigmentosa the disease linked locus has been identified and a novel 7bp deletion has been identified in candidate gene *PRPF31* at the mapped region. A previously unreported mutation has also been identified in *CNGA1* gene.
- In the ongoing project at CCMB, Hyderabad and Brenneckestr, Magdeburg, Germany the molecular basis of biogenesis of calneurons has been described. Calneurons are EF-hand neuronal calcium sensors that are localized at the trans-golgi network (TGN) where they regulate vesicle trafficking from TGN to plasma membrane.

Indo-Sweden

- The major focus of the proposal at IISc, Bangalore and at Uppsala University, Sweden has been to establish and characterize an *in vivo* assay system for initiation of protein synthesis in *Mycobacterium smegmatis*. The assay system has been established however, to establish which amino acid is used to initiate protein synthesis various mutants of the initiator tRNA for its structure-function analysis has been generated.
- In another project at IISc., Bangalore and at Translational Immunology at SMI, Sweden, it was found that expression of Rv3852, a topology modulator protein from *M. tuberculosis* resulted in alteration of nucleoid morphology. Structure of *M. tuberculosis* HU protein was also determined and molecules are now being designed to inhibit its activity.
- and acceptance of spacing methods through a gender-equity focused family planning intervention delivered by the village health care providers.
- Under the ongoing project at ICMR Delhi and Boston University, Schol of Public Health USA, the preparatory activities for one year have been completed which includes procurement of all regulatory approvals of ICMR (TEP, DCGI clearance, Institute Ethics clearance) and finalization of working proposal, Case Record Forms, Instruction manual, Standard operating guidelines, CSpro database, certification training in GCP and Ethics and Investigators' meeting for initiation of the study and training in the conduct of the study. Pre and post-training of Health care Providers' (HCP) was also done.

Indo-US

A joint call for proposal was issued and seven proposals were received:

- At NIIRH Mumbai and Boston University, USA the currently ongoing intervention study is to enhance rural young couple's contraceptive knowledge

Stanford-India Biodesign Programme - A Novel Collaborative Technology Innovation

Stanford-India Biodesign (SIB) programme is a innovation programme to create medical technology innovators in India by involving IITs, leading engineering institutions and partner medical institutions. In India, this programme is centered at AIIMS, and IIT, Delhi. The objective of this programme is to train next generation of medical

technology innovators who will in turn focus on invention and early stage development of low cost new medical technologies for the Indian population. The key steps in the biodesign process are: identify fellows through national competition, create a team and train them in innovation process, identify needs, define prototype profile, relevance, initial product development, preclinical validation, large scale clinical validation and commercialization.

So far, 16 fellows have been trained at Stanford University, USA in clinical immersion process in four batches. These fellows have trained 21 interns in India. Fifth batch has joined Stanford University for training in biodesign process in January 2012 for a period of five months. The fellows of the first batch have established a start-up company and are developing the fecal incontinence device. The fellows of other batches are developing devices such as intraosseous device, limb immobilization device, patient transfer life, mucus dislodging device, etc. Initial prototypes are also being developed for: i) a better way to conduct neonatal hearing screening in resource constrained settings; ii) a better way to conduct screening for retinopathy for prematurity in neonates; and iii) a better way to provide resuscitation in order to manage birth asphyxia in a resource constrained setting.

Four Annual Medtech Summits have been organised so far with the aim to bring together the thought leaders of the emerging medical technology industry in India. The objectives of these summits were to understand the current state of the industry, to identify issues facing it and to delineate key activities that will help chart its future course.

A model of innovation has been created which has resulted in filing of 10 patents (international & national). This includes: i) four complete specifications on: a) Apparatus for vascular access in emergency situation; b) An immobilization device; c) Device for collecting fecal discharge in incontinent patients; d) Transfer sheet; ii) four PCT applications on: a) Device for vascular access; b) A medical device for limb immobilization; c) Device for collecting fecal discharge in incontinent patients; and d) Transfer sheet; iii) two provisional patents on: a) A device and a method for auditory screening; and b) Device for mucus removal and dislodging.

Phase-II of SIB Programme

Phase-II of this programme has been initiated that includes selection/filtration of clinical needs, development of prototypes, validation, animal studies, technology transfer and commercialization. Inter-

Institutional Agreement was revised and executed between Stanford University, Stanford-India Biodesign Centre at AIIMS & IIT-Delhi and DBT. The Fellowship Agreement was formulated and executed with the fellows and interns of 2010 batch. Collaboration has been promoted between the fellows and industries.

Technology Transfer and commercialization

A Technology Transfer Committee has been constituted by the Department to deal with the issues being faced by the Fellows in negotiation with the companies for technology transfer and commercialization. This Committee has negotiated with the industries for transfer of technologies developed at various stages. A number of formats and agreements have been developed and finalized. The Department has engaged Biotech Consortium India Ltd. as a management organization of the this programme. The support services for this programme are also being provided by the Biotechnology Industry Research and Development Assistant Programme (BIRAP).

Khorana Programme for Scholars

Department of Biotechnology, University of Wisconsin-Madison and IUSSTF have partnered to support prestigious Khorana

Programme for Scholars named in honor of Har Gobind Khorana. The Khorana Programme provides an opportunity to Indian scientists (currently enrolled in B.Tech., M.Tech. and M.Sc. programs in Biotechnology and allied areas) to undertake research internships at UW. DBT provides a fellowship grant of US\$ 2,000 for a period of 10-12 weeks. Fifteen candidates were selected for the award of the scholarship.

The programme has been extended for another period of three years. Department has also initiated Technology Transfer Course for Indian Science professionals at University of Wisconsin. This program will benefit DBT, which is in the process of setting up a number of institutes for innovation and translational research as prime mandate.

Indo-UK

Bioenergy has been identified as a scientific area that receives significant funding from BBSRC in the UK and DBT in India; both countries currently invest in second generation and beyond bioenergy and biofuels. Under this cooperation, a joint Indo-UK workshop held in New Delhi in October, 2011 by DBT and BBSRC. As a follow-up, a joint call for sustainable bioenergy research between India and UK will be announced. A total of £ 10 million

would be committed by DBT and BBSRC towards this call. The collaborative programme on bioenergy envisaged in this workshop aims to solve shared problems in the production and processing of plants (mostly waste) and algae for bioenergy. Another joint DBT-BBSRC workshop on "Livestock health and diseases" was held in February 2012 in Delhi.

The University of Edinburgh (UofE) has been actively pursuing collaboration with India in the area of biological sciences. A Letter of Intent (LoI) was signed in January 2012 during the visit of Professor Sir Timothy O'Shea, Vice Chancellor, University of Edinburgh.

Wellcome Trust-DBT India Alliance

The Department of Biotechnology under the Ministry of Science and Technology has partnered with Wellcome Trust (WT) to launch a three-tier fellowship programme on biomedical research at post-doctoral level. The Department of Biotechnology and the Wellcome Trust have committed Pounds Sterling 8 million each year, for a period of five years. The programme is being delivered by a Special Purpose Vehicle (SPV), a public charitable trust registered as The Wellcome Trust/DBT India Alliance with the office situated at Hyderabad. The Trust receives contribution

from both DBT and WT for running the fellowship.

The Wellcome Trust/DBT India Alliance runs three fellowship schemes: **Early Career** (for newly qualified Ph.Ds), **Intermediate** (for those with 4 – 7 years post-Ph.D research experience) and **Senior** (for those with 7 – 12 years post-Ph.D research experience). So far, 50 fellowships have been awarded - 11 under Senior Fellowship; 26 under Intermediate and 13 under Early Career fellowships. This year onward a new fellowship – The "*Margdarshi Fellowship*" has been initiated for scientific leaders who already lead research laboratory and wish to relocate from their current institution within India or overseas.

Indo-EU

An India-EU synchronized joint call on biotechnological waste water treatment and reuse in agronomical systems with • 6 Million from EC side was announced. Five proposals were received.

- Under the ongoing project NAMASTE at North East Institute of Science and Technology partnering with EIRC, UAS Bangalore including partners from Italy, UK, Spain, Hungary and Netherlands, development of pretreatment technologies for stabilization and

preservation of byproducts of food industry and subsequent recovery of useful products under project protocols for stabilization and preservation of rice bran, pomegranate and mango peel waste have been developed. Production of Lactic acid using unsterilized defatted rice bran by simultaneous saccharification and Fermentation are in progress. Enzymatic method for recovery of insoluble dietary fibre for probiotic preparation from rice bran on laboratory scale has been developed. Isolation of dietary fiber from mango and pomegranate peel powder is under progress. Laboratory scale extraction protocol for pectin from pomegranate and mango peel has been completed. Protocol was developed for extraction of total phenolics and natural colour (Anthocyanins) from rice bran. Optimization work for Ferulic acid extraction is in progress. Completed extraction of poly phenols from both pomegranate and mango peel. Protein concentrate from defatted rice bran was extracted by using both alkaline and enzymatic method.

- In another ongoing project being implemented at Annamalai University alongwith NIN Hyderabad and IIT Madras, with partners from Stockholm Univ., Italy, Germany, Serbia and

Karolinska Instt., IC50 values of *Gentianella lutea* extracts (water and methanol extract), astaxanthin and proanthocyanidine B2 on primary cultures of rat aortic smooth muscle cells and on smooth muscle cell lines (A7r5 and HASMC) have been determined. Among the compounds tested for anti-atherogenic property, ellagic acid and water extract of *Gentianella* blocked PDGF-induced smooth muscle cells proliferation. They also blocked PDGF-induced production of nitric oxide (NO) and reactive oxygen species (ROS) in smooth muscle cells. Process of elucidating the signaling mechanisms involved in imparting athero-protective effects of these compounds is under progress.

ERA-NET

Department of Biotechnology is part of the new INDIGO project which is the first European Research Area Network Programme (ERA-Net) in India.

A call for proposals has been announced in the area of biotechnology applied to human health. Some of the achievements under the ongoing project are as follows:

- Under the project (ANTICHIK) being implemented at University of Madras,

BITS, Mesra and Luebeck University, Germany , CHIKV nsp3 macrodomain has been characterized. The ADP-ribose is a well conserved protein bound ligand for the CHIKV nSP3 macrodomain. This is an attractive target for this virus and virtual screening for drug molecules, which can bind at this site and may produce some inhibitory action against chickangunya virus.

- For the execution of project running at AIIMS Delhi and Universitats klinikum Jena, Germany a workshop was conducted in Jena, Germany in November.
- The project at Indian Institute of Technology, Madras (consisting of partners from Germany, Turkey and Austria) aims at developing an early warning system for failure of bileaflet mechanical heart valves by developing a magnetic sensor. Titanium bileaflets have been designed and fabricated. Diamond Like Carbon (DLC) and a magnetic coating (Ni:Fe) have been deposited onto the titanium leaflets. The haemolysis for these coatings have been studied. Results are positive and encouraging.
- In another project being undertaken at Central Drug Research Institute Lucknow and Institute de Biologia,

Spain studies conducted in the insulin resistant rats (High fat fed rats), a representative model of insulin resistance, have demonstrated enhanced free radical generation from neutrophils as well as significant increase in the myocardial injury following coronary artery ligation.

- Under the program PLANTY at National Chemical Laboratory, Pune involving 5 European partners (Austria, Spain, Netherlands, Turkey and Germany), a modest experimental program on value addition to the pomegranate fruit was initiated. 50 kg batches of the variety Bhagwa were processed for recovery of various components of the fruit (arils, peel and pomace). Detailed analysis of each of these components were performed and a material balance for processing of pomegranate was arrived upon for subsequent scaling up. Peel was found to be a rich source of anti-oxidants and animal feed trials are proposed using this material as an ingredient. Similarly, the seed found in the pomace was found to be a rich source (46% w/w) of poly-unsaturated fatty acids (PUFA's). The fruit juice was clarified using membranes and was found to be a very pleasant drink suitable for packaging. Further studies are planned on encapsulation of the anti-oxidants from peel and the seed oil.

- Ongoing project at Central Potato Research Institute, Shimla involving partners from Netherlands, Spain, Germany and UK, expression of the FT analog *StSP6A* this gene was investigated in three Indian potato cultivars, viz. Kufri Giriraj (Long Day), Kufri Arun (Short Day) and Kufri Jyoti (Day Neutral). A correlation was observed between *StSP6A* expression and tuber initiation in case of day-neutral and long-day cultivars. Similarly, expression of this gene was investigated in *Kufri Chandramukhi* (heat sensitive cultivar) and Kufri Surya (heat tolerant cultivar). Expression of *StSp6A* was inhibited at 24°C in heat-sensitive cultivar Kufri Chandramukhi, while in heat tolerant cultivar Kufri Surya induction of this gene was observed even at higher temperature. Expression of this gene was induced during tuberization at 18°C in both the cultivars.
- Four kinds of magnesium based biodegradable alloys have been tested at CCMB, Hyderabad, as implants in bone injury models created in rabbits and found that the MgZrSr₂ alloy is found to be the most efficient.
- To improve management of diabetic ulcers, 510 wound samples from diabetic ulcer patients have been collected and microbes isolated and identified at Manipal Life Sciences Centre (MLSC), Manipal. Antimicrobial profile and biofilm producing capability of these microbes are under study to identify suitable biomarkers for rapid diagnosis.
- The Veterinary College, KVAFS University, Bangalore and Ella Foundation, Hyderabad have jointly developed a PCR for identification and capsular typing of *Staphylococcus aureus* as a part of development of an effective vaccine for the prevention of staphylococcal mastitis in bovines.

Indo-Australia

A joint call for proposal under the sixth round was announced this year and proposals were invited in the areas of Stem Cells; Vaccines/ Medical Diagnostics; Transgenic Crops and Marker-assisted Breeding; and Bioenergy & Biofuels. Highlights of some of the projects supported under this collaboration are given below:

- In order to develop a high salinity and drought tolerant rice (in India) and wheat (in Australia) varieties gene constructs (*Gly I*, *Gly II*, and *PDH45* genes) have been prepared at ICGEB and transferred to Australian collaborators. The rice plants have been grown under stress conditions for further study.

Wheat transformation has already been set up by Australian collaborators with these constructs.

- At IARI, Delhi, transcriptome sequencing of wheat cyst nematode, *Heterodera avenae* an important pest of wheat has been initiated. This is first report of illumina sequencing platform used for transcriptome sequencing of plant parasitic nematodes.
- Various sorghum varieties from India by ICT, Mumbai and Australia were screened for extraction of kafirin. Kafirin, a prolamin protein was successfully extracted from sorghum and characterized by various analytical techniques.
- In the project at ICT Mumbai, a Novel process for extraction of kafirin from sorghum seeds and Kafirin based nanoparticles as novel drug delivery system (NDDS) have been developed. Preliminary studies have shown better anticancer effect of this formulation than that of standard drug.
- Variations in the *CYP1B1* gene have been found to cause autosomal recessive Primary Congenital Glaucoma (PCG) in several world populations. However, in India PCG appears to be highly

heterogeneous genetically. A genome-wide approach has lead to the identification of two important genes, namely *KLHL26* and *TSHZ2* may carry mutations that cause PCG in the Indian population.

Indo-Norway

A Multicentric Indo-Norwegian programme on vaccine platform in the area of aquaculture was continued this year.

- Work on Development and evaluation of bacterial (*Aeromonas hydrophila* and *Edwardsiella tarda*) vaccines for finfish based on outer membrane proteins (OMP) was initiated at College of Fisheries Mangalore. *Aeromonas hydrophila* and *Edwardsiella tarda* is responsible for serious economic losses for fish-farming industry due to serious disease manifestation. Recombinant vaccines were developed against these pathogens. These vaccines were tested for immunogenicity in fishes. The study indicates the potential of the OMPs for protecting carp and rohu through vaccination.
- In another programme, work on immunomodulation studies in freshwater prawn *Macrobrachium rosenbergii* using three recombinant

proteins of *Macrobrachium rosenbergii* nodavirus was carried out with the collaborative efforts of CIFA and CIBA. Based on the sequence analysis of three MrNV genes (Capsid, RdRp, B2), the tertiary structure was predicted. The MrNV RdRp and capsid protein were able to reduce the viral load indicating that these proteins may act as immunomodulators against white tail disease (WTD) in *Macrobrachium rosenbergii*.

DBT-IAVI Collaboration

The collaborative programme has been further extended for another period of 5 years w.e.f 7th July, 2010. Under the aegis of Indian Medicinal Chemistry Programme, 2 projects have been funded and the funding will continue for next phase. The study at ICGB, New Delhi focuses on development of conformationally preferred peptide immunogens as candidates against HIV-infection. The emphasis is on designing peptide immunogens to elicit HIV-1 neutralizing monoclonal antibodies. Study at IISc, Bangalore is directed towards designing and characterization of novel Outer Domain (OD) derived immunogens with additional mutations to prevent protein aggregation. The significant outcomes from the studies have been patented.

THSTI-IAVI HIV Vaccine Research Programme

THSTI and IAVI have agreed to set up a collaborative effort towards advancement of innovation, facilitate collaboration, build centres of excellence and invest in next generation of scientists and to accelerate the HIV Vaccine discovery program. The key components would be designing, testing and implementing high-throughput strategies for HIV-1 envelope-based immunogen screening and prioritization to help discovery and advancement of novel HIV vaccine candidates. The program is targeted to expand the number of vaccine candidates globally for testing, and enhance the speed with which they can be assayed. The unique industrial-type high-throughput vaccine design, screening and selection processes proposed for the THSTI-IAVI HIV-1 Vaccine Lab will be largely facilitated by interdisciplinary interaction and will be driven by the principles of international collaboration, high-quality science and vaccine-oriented research.

Indo-Swiss Collaboration

The Indo-Swiss Collaboration in Biotechnology programme started in 1998 with an agreement between Department of Biotechnology and Swiss Agency for Development and Cooperation with the

mandate to develop products and biotechnological processes, which have an impact on poverty alleviation and sustainable management of natural resources in India; to focus on innovative technologies in agriculture and environmental research and; to build capacities and R&D partnerships between Swiss and Indian institutions and private companies with strong economic, social, and ecological relevance.

Currently, the programme is in its third phase (2008-2011) involving 120 researchers including private sector aiming at technology development and advancement by validating various projects of phase-II in terms of prototype products. During the third year (2010-2011) of this phase, two main activities viz. the Technology Advancement Unit (TAU) was established and the South-North-South collaboration in pulse technologies at the BARI (Bangladesh Agricultural Research Institute) was identified as a possible institute for collaboration.

- In the Pulse Network project in an effort to develop Aphid resistant chick pea plants, being executed at Bose Institute, Kolkata successful multiplication and analysis of transgene expression of existing transgenic chickpea lines developed with chimeric *Allium sativum*

leaf agglutinin (ASAL) gene constructs under CaMV35S promoter and phloem tissue specific *rolC* promoter were performed. The preliminary results of biosafety analysis indicate that ASAL may be considered as apparently safe molecule.

- In another project executed under the pulse network at Assam Agricultural University, Jorhat, in collaboration with ICRISAT, Patancheru, India transgenic lines of chickpea carrying the chimeric Bt-Cry2Aa gene to confer protection against pod borer (*Helicoverpa armigera*) have been generated at AAU. The transgenic seeds were transferred to ICRISAT.
- The biofertilizer network aims at producing plant growth promoter bacteria and Mycorrhizal formulation for enhancing nutrition mobilization and uptake in cereal and pulses. TERI has successfully developed a consortium of Arbuscular Mycorrhizal Fungi (AMF) and Plant Growth Promoting Rhizobacteria (PGPR) which were tested in multi-location field validation trials in low input agricultural fields for enhancing wheat productivity.
- In a project executed under biofertilizer network at GB Pant University of Agriculture and Technology (GBPUAT),

Department of Biological Sciences, Pantnagar, India a combination of consortia AMF and two of the Plant Growth Promoting Rhizobacteria (PGPR) have been optimized for commercial production.

- Under the wheat network, projects were supported for fungal disease resistance and terminal heat tolerance in wheat. At PAU, Ludhiana a recombinant inbred line (RIL) population derived from the cross *Triticum boeoticum* / *T. monococcum* was developed and the genes Leaf rust resistance, stripe rust resistance, and powdery mildew resistance were mapped. Under another project Directorate of Wheat Research, Karnal, has identified identify molecular markers linked to the genes for stripe rust resistance for accomplishing marker assisted pyramiding, using three recombinant inbred line (RIL) populations developed from the crosses Cappelle Desprez and its substitution line Cappelle Desprez (Mara-2D); Capelle Desprez / PBW343 and Capelle Desprez (Mara 2D) / PBW343. In a yet another project, for molecular mapping and identification of QTLs for heat stress tolerance, parental screening with more than 375 SSRs and screening of the RIL population with about 75 SSRs have been accomplished. In order to develop wheat cultivars with greater yield at high temperatures, it is essential to understand the effects of high temperature on the process of starch accumulation. Two wheat genotypes; Halna (heat tolerant) and Raj 4014 (heat susceptible) were exposed to higher temperature during the grain filling. Primers for genes; ADP-glucose pyrophosphorylase (large and small subunits), SSI and SSIII amplified the desired product.
- NCL, Pune has transferred the mycoinsecticide technology to the private sector viz. HiTech Bioscience India Ltd. (HTBS), Pune. The mass production of *Metarhizium conidia* strains using solid state fermentation (rice as substrate) was carried out at at NCL and the optimization for large scale production of the same was done at HTBS for commercial strain M34412. Desired modifications were done by manufacturer Wadegati Labequip Pvt. Ltd.
- Full-length genomes of viruses associated with the cassava mosaic disease were cloned and sequenced from five cassava genotypes collected at six locations in South India at MKU, Madurai. The RNAi constructs have been transformed in tobacco to assess its role in disease control in cassava.

Indo -Tunisia

A 'Programme of Co-operation' (POC) signed between Republic of India and Republic of Tunisia in 2006 for five years in the area of biotechnology with an objective to develop and support collaborative research activities in the area of agriculture and health care. The POC is extended recently for another five years on mutual agreement with a commitment to cooperate for fruitful outcomes.

Indo-France

A 'Memorandum of Understanding' (MOU) signed between India and CNRS, France is recently renewed with an objective to establish International Associated Laboratories (LIA) in the area of biotechnology as well as to launch a new International Masters and Ph.D. The new programmes are under discussion for signing the necessary agreements

Indo-Japan

DBT, India and AIST, Japan has initiated eight major projects in the area of bioinformatics and cell engineering.

- The bioinformatics projects which were sanctioned in 2009-2010 utilize bioinformatics tools to analyze sequence

and structure of target molecules with potential applications in creating the artificial proteins for engineering. The projects comprise of four challenging themes in the area of Bioinformatics. These include (1) Designing potential targets in membrane proteins, (2) Designing GPCRs Mimetics (3) Designing FIXER for disorders, and (4) Designing cybrog lectins. Computational Biology Research Centre (CBRC), Tokyo, a constituent institute of AIST has been engaged for these projects with six major institutions in India.

- Four projects have also been launched last year in cell engineering to identify novel drug targets and therapeutics for cancer. The projects involve (i) Understanding molecular mechanisms controlling dual role of Ras, Sirtuins and CARF in relation to cellular proliferation and senescence, (ii) Studying the Role (s) of Mortalin and CARF networks in ovarian cancer, (iii) Studying the use of Ashwagandha derived phytochemicals for development of differentiation-based therapy of brain cancers, and (iv) Insights into secondary metabolite production and their accumulation in *Withania somnifera* using in vitro propagation

system. The Cell Engineering Institute of AIST at Tsukuba is working with four major institutions from India for these projects.

All these developments have been reviewed by the Joint Committee of Indo-Japan during the 4th bilateral Workshop which was organized in India on 13-14 December, 2010.



AUTONOMOUS INSTITUTIONS

National Institute of Immunology (NII), New Delhi

NII, New Delhi continued its activities to promote and conduct high-quality research in the area of immunology and related sciences. The core areas of research include infection and immunity, molecular design, reproduction and development and gene regulation. Significant achievements in these areas during the year are as follows:

In the field of basic immunology, the major scientific findings included deciphering the role of Bruton's tyrosine kinase, a kinase implicated in primary immunodeficiency disease, in macrophage cell death. Studies with inflammatory disorders showed that anti-hemoglobin autoreactive antibodies occur quite frequently in humans was due to release of hemoglobin and have inflammatory consequences.

Studies on mechanisms of cancer induction, discovery of biomarkers and improvement of therapy provide key insights into the role of PGC-1 α , a primary regulator of energy metabolism in mediating p53 action.

An effort in cancer biomarker discovery shown sperm-associated antigen 9 is involved in tumorigenicity as well as tumor growth. Effective combination treatment for teratocarcinoma, the cancer of the testis, by a combination of cisplatin and a plant flavonoid fisetin is providing a lead for formulation of better treatments.

A number of promising leads were reported on the biology of *Mycobacterium tuberculosis*. HisB, an important protein in the histidine-biosynthetic pathway of *Mycobacterium tuberculosis* was crystallized and preliminary X-ray crystallographic analysis reported. In another project the mechanisms of infection by *Mycobacterium tuberculosis* studies suggests that the PE family of proteins are possibly related to latency, where *Mycobacterium smegmatis* was used as a model to overexpress PE proteins.

Japanese encephalitis virus (JEV) showed the binding of La protein, a protein that associates with many small RNAs to the 3' - and 5' -noncoding regions of the JEV genome. Mechanisms of infection studies with HIV virus showed that human T cell apoptosis occurs through p53 mediated

pathway due to inhibition of ubiquitination of p53 by the HIV protein Vpu. Investigations into the mechanism of influenza virus survival showed that the cleavage of the M1 gene of the virus was significantly augmented when designed antisense molecules hybridized close to the cleavage site.

The c-kit, the master signalling molecule of haematopoietic stem cells helps in early recovery of the haematopoietic compartment in irradiated hosts. In another study with Hemophilia A, which is caused by mutation in factor VIII gene in humans, it has been shown that bone marrow derived hepatocytes and endothelial cells can synthesize FVIII in liver and correct bleeding phenotype in Hemophilia A mice.

A cytochrome P450 protein identified as CYP5122A1 is an important molecule linked to processes like cell growth, infection and ergosterol biosynthesis in the parasite *Leishmania donovani* thus providing a lead for future drug development. Bromo-benzothiophene carboxamide derivatives have been shown to be potent inhibitors of *Plasmodium* sexual blood-stages both *in vitro* and also in the mouse model.

Dissemination of scientific information through professional journals to the worldwide community of scholars and

through symposia, conference and public lectures to the community at large is a basic mandate for NII. An International Symposium on Cancer Biology was held at the Institute provided timely and critical information on how to take an idea from the laboratory to the clinic and consequently to the market place.

Training programs to postgraduate students, short-term training for project work or dissertation provided. The robust Ph.D programme registered 35 students during the year for Ph.D. degree while 27 students received Ph.D. degree during 2011-2012 with academic affiliation of Jawaharlal Nehru University, New Delhi. An agreement was signed with the National Cancer Institute in the US for undertaking clinical trials at the Sloan Kettering Memorial cancer hospital in New York to focus work on cervical cancer, the vaccine's efficacy against ovarian cancer. NII has been involved in clinical trial of Rotavirus vaccine developed to reduce the incidence of diarrhea or its severity in neonatal children continues. NII published 109 high quality research papers in peer-review journals.

National Centre for Cell Science (NCCS), Pune

NCCS is committed to its contribution towards Human Resource Development, by

way of reaching out to individuals at all levels including students, teachers and researchers in India. Basic training as well as custom-made programmes depending on specific requirements of smaller groups of researchers were conducted at NCCS and at the user's end. In the past year, NCCS has provided training to over 17 researchers from various organizations across the country, and 12 students have successfully completed PhD at NCCS. NCCS has supplied over 2300 cell lines to 120 organizations.

The institute focuses on important questions relevant to human health, specifically in the area of regenerative medicine, infectious diseases and lifestyle induced health adversities. In stem cell therapy the procedures for isolation, expansion, cryo-preservation and differentiation of stem cells into specific cell types have been optimized. Considerable efforts are also being made to understand the cellular and molecular mechanisms defining stem cell niche in normal organs (Fig. 10.1).

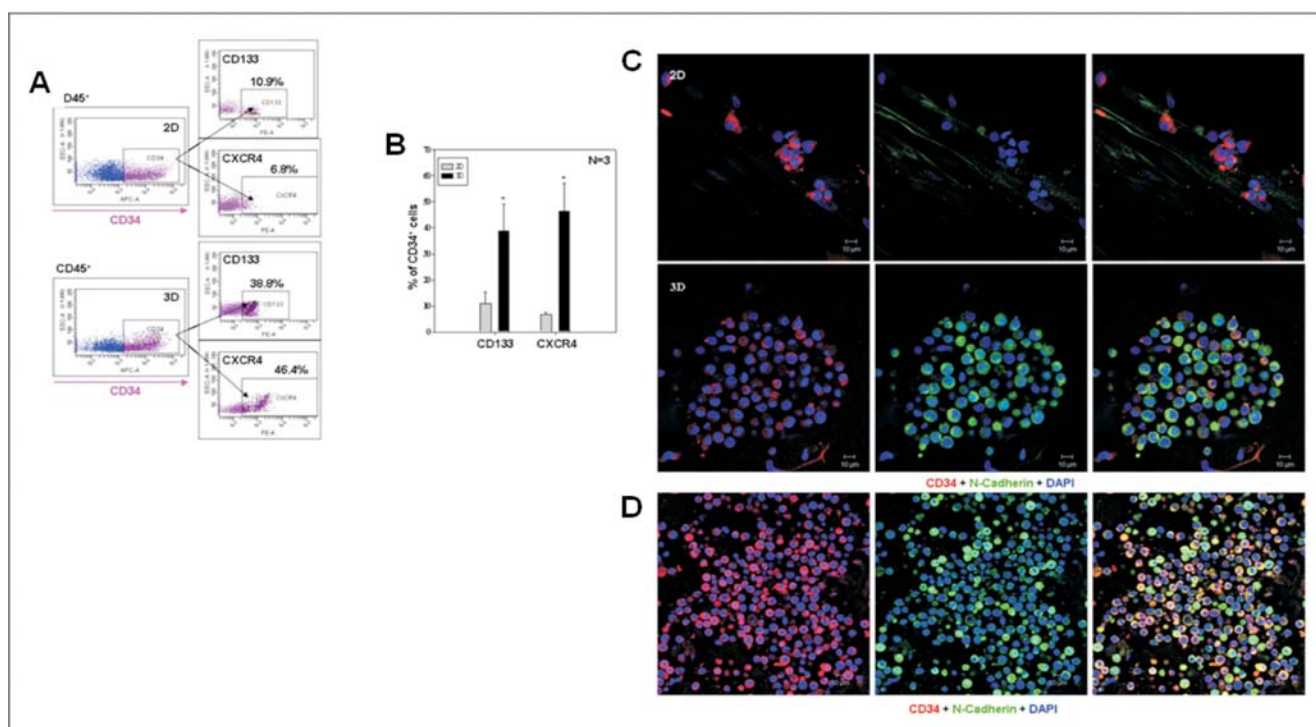


Fig. 10.1: 3D- Mesenchymal Stem Cells Foster primitive stem cell pool, (A) 3D-CD34⁺ cell population contained significantly higher percentage of cells expressing primitive HSC-markers: CD133 (upper panel) and CXCR4 (lower panel)(B)Data from three independent experiments are depicted (N=3), (C) Most 3D-CE34⁺ cells (Cy3) express N-Cadherin (FITC), albeit at variable levels. (D) Huge expanse of DC34⁺ N-cadherin⁺ cells under 3D-conditions. (Tile mode, pixel size 2048x2048), DAPI (blue) demarcates nuclei (blue).

Scientist at NCCS studied immune system functions to evolve mechanisms leading to infections, identifying molecular players involved in host-pathogen interactions in developing strategies to combat infections. Towards this studied the mechanism of viral evasion of human complement system, regulation of CD40 signaling in host cells during Leishmaniasis, protein trafficking in Leishmania, HIV biology and host-pathogen interactions during Plasmodium, Mycobacterium and Candida infections. Hyper-activation of immune system is frequently observed in many inflammatory and autoimmune disorders. NCCS is investigating the role of the chemokines that are involved in regulating these processes.

Cancer is a complex disease caused by mis-regulation of signalling networks. In order to understand the biology of tumourigenesis, NCCS is exploring pathways involving critical players in different signalling cascades involving Osteopontin, eNOS, p53, Cyclin D1, Snail, Slug, mTOR, Wnt, etc. Efforts are made to elucidate the molecular networks underlying oncogene induced senescence. The outcome from these studies is expected to provide tools for better treatment of cancer.

Epigenetic regulation of gene expression plays an important role in various cellular processes. Scientists at NCCS have shown

that nuclear matrix associated proteins like SATB1 and SMAR1 regulate global gene expression by chromatin remodelling. Currently, we are exploring the functions of these two players in immuno-modulation and tumourigenesis.

Diabetes is a multi-factorial metabolic disorder and the incidence of it is increasing at an alarming rate. NCCS focuses on understanding the mechanisms involved in endocrine pancreas development and regulation of insulin biosynthesis. Scientists have identified the molecular mechanisms regulating the insulin production and the intricate relationship between the diabetes-induced cardiomyopathy and oxidative stress. Osteoporosis is another major disease that affects a large proportion of our population, which is caused by the imbalance in bone formation and resorption. Researchers have shown that immuno-modulators like IL3 play an essential role in differentiation of osteoblasts and thereby augmenting the bone regeneration.

The challenge in understanding biological processes is deciphering the underlying complex and dynamic networks. System biology approach is focused on delineating these networks and their interactions. Integrating the de novo drug design, abstract fragment based drug design and

sophisticated molecular simulations is a thrust area of research at NCCS.

Microbial flora within an organism influences the metabolic processes of the host. Using advanced molecular methods such as whole genome sequencing and meta-genomic analysis, efforts are made to unravel the complex microbial ecosystem in the mid-guts of humans and insects of clinical importance. For the conservation and exploitation of biodiversity in India, microbial culture collection centre (MCC) was established in NCCS, with a special mandate from DBT. The centre focuses on basic research in the areas of microbial diversity, taxonomy, genomics and proteomics, in addition to its role as a National facility for microbial culture collection and International Depositary Authority. NCCS has undertaken the efforts to identify novel biomarkers for breast cancer, using integrated proteomic, genomic and bioinformatic approaches. Also, biomolecule mining from hitherto untapped sources such as marine organisms and plants have been performed at NCCS that would aid in treatments of AIDS, diabetes, malaria and osteoporosis.

The institute provides state of the art infrastructure facilities to its scientists. As a part of this process, we have LC-MS, MALDI-TOF, Confocal and high throughput

DNA Sequencer. The challenge for biology at present is the need to deal with the incredibly complex and enormous amount of data generated. To this end, a high performance computing machine have been procured and installed, which provides access to a scalable pool of computing resources.

NCCS has published over 50 scientific papers in peer reviewed journals in the reporting year. The scientific activity at NCCS is facilitated by funding from various national and international agencies.

National Brain Research Centre (NBRC), Manesar, Haryana

NBRC continued its mandate and focused its research and development activities on inter disciplinary science from molecular biology and genetics through psychology to neuro-medicines and bio-engineering. Scientists gave focus on encompassing molecular systems, cognitive and computational neuroscience and work on physiological processes that underpin the normal functioning of the brain as well as major classes of brain disorders, such as neurodegenerative, neuro-oncological, infective, developmental and neuropsychiatric ones. NBRC is also conducting research on infectious agents including Japanese encephalitis, HIV and Prion

diseases. As neuron-glia crosstalk is recognized to be pivotal to normal brain functions, the NeuroAIDS laboratory has broken new ground by establishing a well characterized human neuron-glia co-culture system that is used for unravelling intricacies of neuron-glia communication. Researchers are expected to develop capabilities with human brain cell culture system to better understand HIV-1 proteins modulate neurocognitive functions in HIV/ AIDS patients.

Importantly, NBRC's endeavor from the "the bench to the bedside" has finally become a reality. Leads of the scientific discoveries that minocycline can be used for the treatment of Japanese Encephalitis has been cleared by the Drug Controller General of India for a Phase II clinical trial at CSM Medical University, Lucknow. Research group investigating the pathogenesis of Angelman's syndrome has found that chronic stress due to altered glucocorticoid receptor signalling might lead to cognitive deficits and anxiety-like behaviour in a mouse model of Angelman's syndrome.

Faculty is focussing work on translational neuroscience and computational neuroimaging and has developed new methodologies including energy flow mapping and thermal conduction tensor imaging to predict the occurrence of

Alzheimer's disease. Image-guided therapy of stroke and vascular dementia has been optimized. Work pursued on neurospectroscopy has broken new grounds in the measurement of metabolites in the brain as regards sensitivity and specificity and is being used to answer questions of biological relevance. The Speech and Language Laboratory (SALLY), which has been investigating the development of cortical circuits for reading two languages (English and Hindi) that differ in script and orthography (sound-letter mapping), has shown the existence of distinct reading circuits for the two languages.

New initiatives taken during the year

A Centre for Excellence in Epilepsy centred round a Magnetoencephalogram (MEG) has been initiated in NBRC in collaboration with AIIMS. Investigators from both AIIMS and NBRC would be using this equipment, which would also be developed as a National Facility for use in a wide variety of disorders in addition to epilepsy studies as well as in the study of normal functioning of the brain.

National Program on Perception Engineering

A programme was undertaken to develop technology inspired by the brain

mechanisms of perception by involving collaborations between NBRC and engineers and cognitive scientists from seven institutes across the country with the funding of the Department of Information Technology. The goal of multidisciplinary program are investigations on the fundamental issues of perception and cognition, development of models of perceptual and cognitive processes for technology development and generate know-how for new information and communication technologies motivated by the models of perceptual & cognitive processes. The institute has also undertaken various Bilateral/ Multilateral Agreements with the United States, Japan, Italy, The Netherlands, Canada for joint R&D and networking of research.

Further details may be seen on the website www.nbrc.ac.in.

Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad

CDFD has provided services in the areas of DNA fingerprinting and diagnostics testing for genetic disorders and also pursued various research aspects in molecular biology.

Services

DNA Profiling: DNA profiling services, 112 cases were forwarded to CDFD by the judiciary and law enforcing agencies out of which majority were related to identification of the deceased (57) and maternity/ paternity disputes (40) and 14 states of the country availed DNA fingerprinting services of CDFD. Rajasthan forwarded 37 cases,

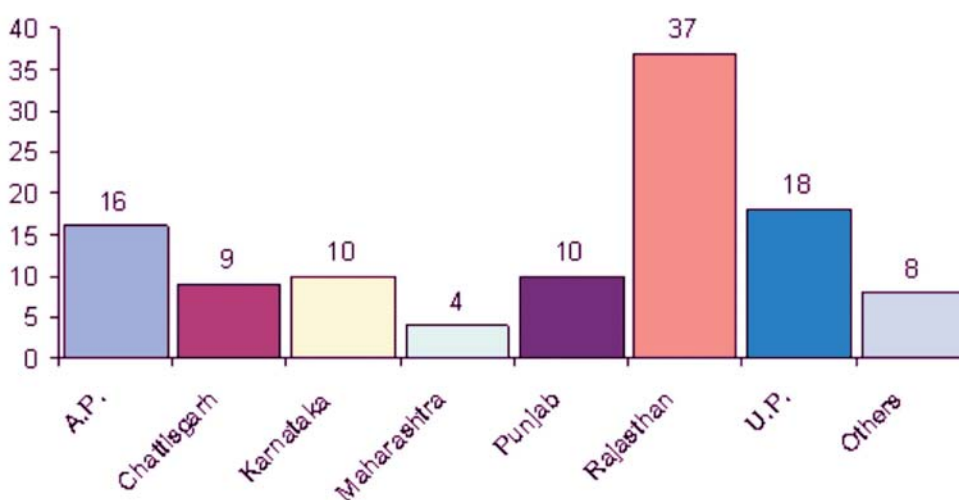


Fig 10.2: Details of the state-wise cases received

followed by 18 cases from Uttar Pradesh, 16 from Andhra Pradesh, and 10 cases each from Karnataka and Punjab (Fig. 10.2). Training on DNA fingerprinting examination was provided to personnel from the State Forensic Science Laboratory, Uttar Pradesh and Andhra Pradesh medical College, Visakhapatnam.

New initiatives taken in DNA profiling for providing services to demonstrate the power of expanded application of the technology improving the system of criminal justice delivery in the country. An MoU was signed with Institute of Life Sciences (ILS), Bhubaneswar and State Government of Orissa, to establish its laboratory in ILS and participate with the Govt. of Orissa to provide DNA profiling services.

Diagnostics: The Diagnostics Division is providing genetic evaluation and

counselling to patients (as part of its efforts to undertake research in the area of Mendelian genetic disorders in humans) has successfully dealt with about 1650 cases this year.

New initiative taken on established of The Medical Genetics Unit at Nizam's Institute of Medical Sciences, Hyderabad. The unit has been operating successfully to offer outpatient referral services, and the process of creating a Department of Medical Genetics for undertaking research and superspecialty training programs in clinical genetics. An application to Medical Council of India has been submitted by the CDFD to that effect.

APEDA-CDFD Centre for Basmati DNA Analysis: Based on one of the DNA inventions developed and patented by the Centre, the Agricultural Products Export

Genetic investigations done during the year		
Investigation	Total cases	Positives
Cytogenetics	774	77 (9.9%)
Proband	695	72 (10.3%)
Prenatal	79	5 (6.3%)
Molecular Genetics	593	254 (42.8%)
Proband	565	247 (43.7%)
Prenatal	28	7 (25 %)
Biochemical Genetics	655	167 (25.5%)
Proband	640	162 (25.3%)
Prenatal	15	5 (33.3%)

Development Authority (APEDA) of the Govt. of India has entrusted CDFD with the task of certifying the quality and authenticity of basmati rice. During 2011, 205 basmati samples were analyzed. Since the testing was introduced about 7 years ago, the proportion and magnitude of adulteration has progressively decreased - attesting to its deterrent value.

Research

The institute has taken up various research and developmental activities during the year and pursued several frontier areas of

modern biology, with a group of approximately twenty faculty-level scientists. The major thrust areas include computational biology and bioinformatics, structural and molecular biology, genetics and epigenetics, silkworm genomics, molecular pathogenesis, cancer and stem cell biology, molecular and cellular biology, fundamental studies on transcription and signal transduction, and plant biology. A glimpse of research activities at CDFD are given below:

Silkworm Genetics and Genomics: The Centre has identified and characterised sex

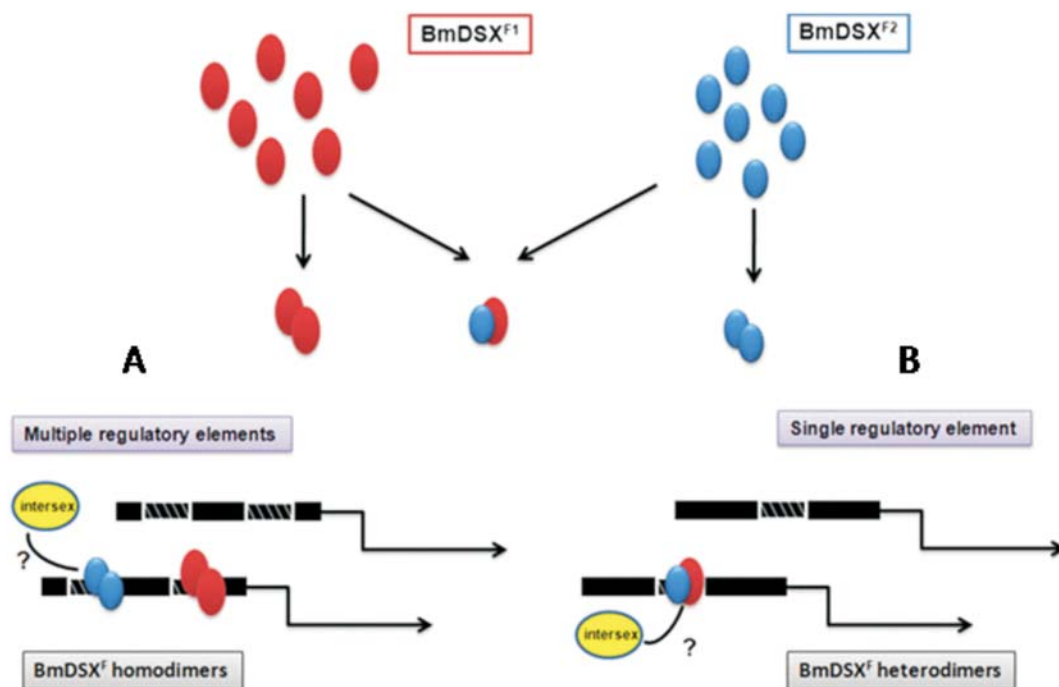


Fig. 10.3: Model explaining the mode of action of two BmDsx proteins in females. A) Two different regulatory elements (RE) are present in the promoters of downstream target genes (*vitellogenin*, *SP1-Storage Protein* and *PBP-Pheromone Binding Protein*). Homodimers of BmDsx bind separately to these regulatory elements to independently regulate them. B) alternatively, heterodimers of BmDsx bind to the single regulatory element present in the promoters of downstream target genes to regulate their expression. Products of intersex gene may also possibly interact with BmDsx.

determining genes – the homologs of *doublesex* (*dsx*) and *intersex* (*ix*) genes in *Bombyx mori* as well as in wild silkmths, *Antheraea assama* and *A. mylitta* (Fig. 10.3). The group has identified four *B. mori* nucleopolyhedrosis virus encoded miRNAs using a combination of *in silico* and experimental methods and has computationally predicted 8 viral and 64 cellular targets of these virus-encoded miRNAs. The putative functions of these targets suggest a key role of viral miRNAs in insect-pathogen interactions by modulating several viral replication genes as well as those involved in host immune defense machinery (Fig. 10.4).

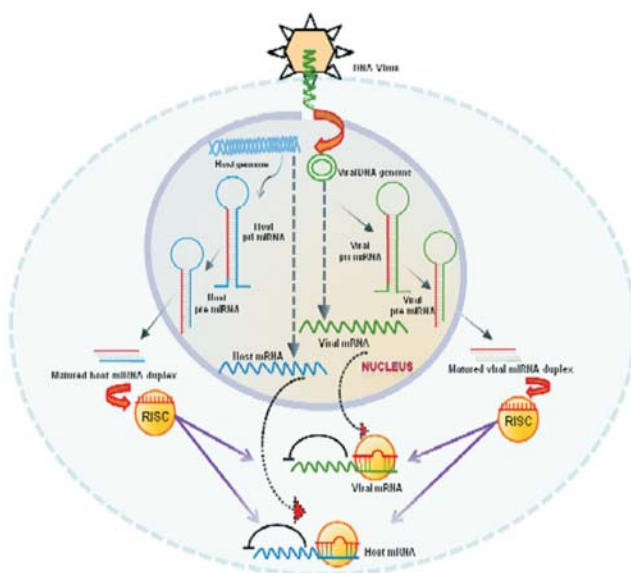


Fig. 10.4: Schematic overview of the role of miRNAs in host virus interaction.

Structural Biology: The Centre has carried out ChIP-chip experiments in *Mycobacterium tuberculosis* using monoclonal antibody raised against GroEL-1. The analysis of

microarray data revealed that out of the 240,000 probes, approximately 2400 probes are enriched for binding. Gene-based enrichment showed that this corresponds to 357 genes out of the ~4000 genes in the genome of *M. tuberculosis*. An interesting outcome of this analysis was that the GroEL1 binds predominantly to the coding region, and to GC-rich regions. Enrichment in the coding region of the PE-PGRS genes was also observed. The results of ChIP-chip were confirmed by PCR amplifications of the bound probes, and by electrophoretic mobility shift assays of identified consensus sequences. These results were further confirmed by Surface Plasmon Resonance with the oligonucleotide sequences designed using the consensus obtained from ChIP-chip analyses.

Bacterial Genetics: Through the Centre's work in the area of Bacterial Genetics, a role for NusA in Rho-dependent transcription termination in *Escherichia coli* has been demonstrated, and a model has been proposed for modulation of the termination mechanism by the H-NS family of nucleoid proteins. R-loops formed in strains defective for Rho-dependent termination appear to provide a bypass mechanism for the absence of two pathways of RNase E. Finally, several new targets of the ArgP transcriptional regulator have been

identified, including *lysP*, *dapD*, *asd*, *lysA*, and *lysC* (Fig. 10.5).

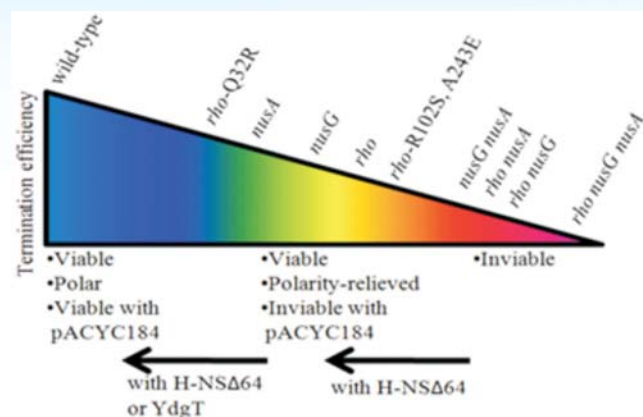


Fig. 10.5: Spectrum of Rho-dependent transcription termination efficiencies in different mutants, and the effects of H-NS Δ 64 or YdgT thereon. The designations *rho*, *nusG* and *nusA* without suffixes refer, respectively, to *rho*-A243E, *nusG*-G146D, and *nusA*-R258C mutations.

Transcription: CDFD has been engaged in understanding the molecular basis of factor-dependent transcription termination and antitermination in *Escherichia coli* and has been able to demonstrate the generalized existence of kinetic-coupling in the Rho-dependent transcription termination. Studies have shown the requirement of nascent RNA in the recruitment of Rho to the elongation complex. The group has proposed an inhibition/antitermination hybrid model for overcoming the Rho-dependent termination by N (Fig. 10.6).

Cell Signalling: The Centre has been studying the regulation of eukaryotic cell

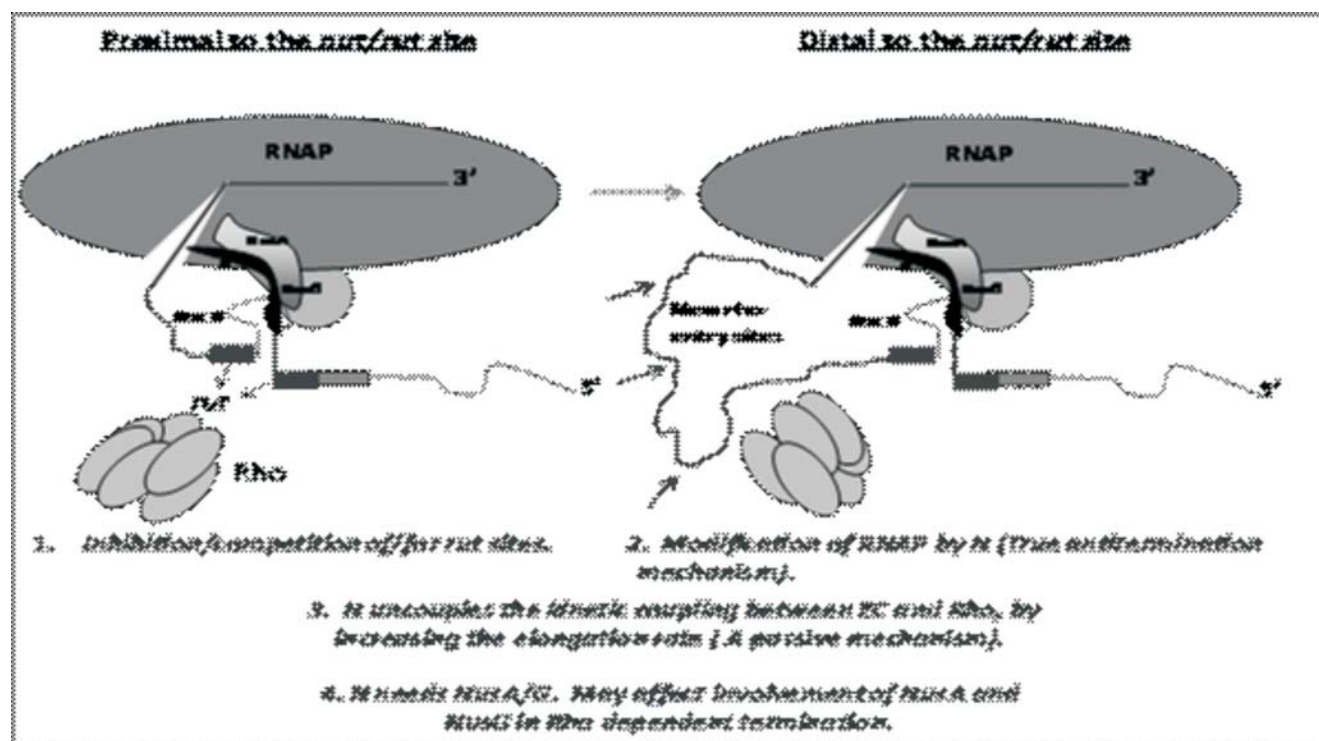


Fig. 10.6: Possible mechanisms of overcoming the Rho-dependent termination by N.

physiology by inositol pyrophosphates. Yeast lacking inositol pyrophosphates display defects in ribosome biogenesis, reflecting the regulation of rRNA transcription by IP_7 . Gene expression analysis of mammalian cells with reduced IP_7 has led to the identification of a role for inositol pyrophosphates in regulating actin cytoskeleton dynamics and cell migration.

Computational Biology, Bioinformatics and Functional Genomics: The major activity of computational biology group at CDFD pertains to analyses of protein-protein interactions under different contexts such as role of intrinsically disordered proteins in human-Virus (Hu-Vir) protein-protein interaction network, construction and comparison of human tissue-wise protein-protein interaction networks and structural and functional characterization of hubs in human PPI network. A novel, high performing SVM-based method to predict disease and neutral nsSNPs has been developed by the researchers in this group. Projects related to identification and characterization of promoters and transcription factor binding sites in *Mycobacterium tuberculosis*, reconstruction of a genome-wide protein-protein functional linkage map of *Escherichia coli*, and genome analysis of *Plasmodium falciparum* to understand the effect of AT-richness on the proteome, have been carried out.

Mammalian Genetics, Molecular Oncology and Immunology: Laboratory of Mammalian Genetics has shown that a strong correlation exists between the DNA methyltransferase *DNMT3L* involved in epigenetic reprogramming and carcinogenesis unlike other DNA methyltransferases, *Dnmt2* has been shown to be involved in RNA processing during cellular stress. Results from the Molecular Oncology group of the Centre have provided insight into the distinct clinical behaviour of early-onset rectal cancer. *ARID1B*, a component of the SWI/SNF chromatin remodelling complex has been shown to be likely novel tumor suppressor gene for pancreatic cancer. The Laboratory of Immunology has been involved in detecting the role of Ras and p53 on doxorubicin-mediated apoptosis (Fig. 10.7).

Plant-Microbe Interactions and Fungal Pathogenesis: The researchers in the Laboratory of Plant-Microbe Interactions are studying the dynamics of DSF mediated quorum sensing in individual cells. A novel outer membrane localized adhesin, XadM, of *Xanthomonas oryzae* pv. *oryzae*, which is required for virulence has been isolated. A group has uncovered a novel role for a glycosylphosphatidylinositol (GPI)-linked aspartyl protease, CgYps1, in the regulation of pH homeostasis in *C. glabrata* under acidic environmental conditions, a pre-requisite for survival in host niches of

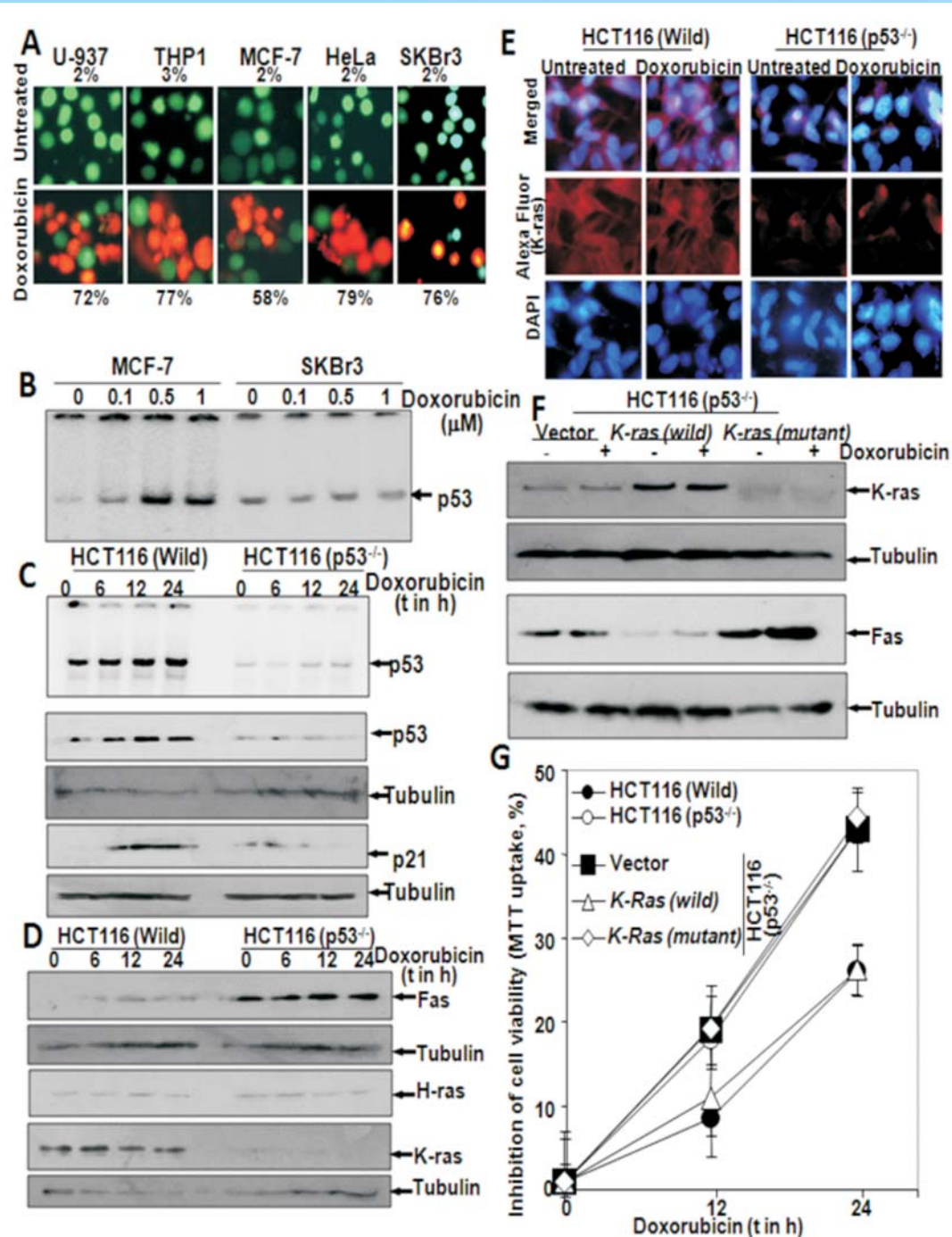


Fig. 10.7: Ras puts brake on doxorubicin-mediated cell death in p53 expressing cells. Doxorubicin induced more cell death in p53 negative cells (U-937, THP1, SKBr3, and HeLa) than p53 positive (MCF-7) cells as shown by Live&Dead assay (A). Doxorubicin increased p53 DNA binding in MCF-7, but not SKBr3 cells (B). Doxorubicin increased p53 DNA binding and p53 and p21 expression in HCT116 p53 positive cells (C). The expression of Fas increased, but K-ras decreased in p53 negative cells as shown by Western blot (D) and immunofluorescence study (E). Overexpression of wild type K-ras in p53 negative cells decreased basal expression of Fas (F). K-ras overexpressed p53 negative cells showed less sensitive to doxorubicin-mediated cell death (G)

varied pH. A set of 102 genes in *C. glabrata* which contribute to its survival/replication in the intracellular milieu of macrophages have also been identified (Fig. 10.8).

National Institute of Plant Genome Research (NIPGR), New Delhi

The National Institute of Plant Genome Research (NIPGR) has taken up research programmes in Computational Biology,

Genome Analysis and Molecular Mapping, Molecular Mechanisms of Abiotic Stress Response, Nutritional Genomics, Plant Development and Architecture, Plant Immunity, and other Emerging Areas. A bird's-eye-view of some of the scientific achievements of the Institute for the period under report is as follows:

Bioinformatics: facility at the Institute and has been strengthened. An automated procedure was developed for identification

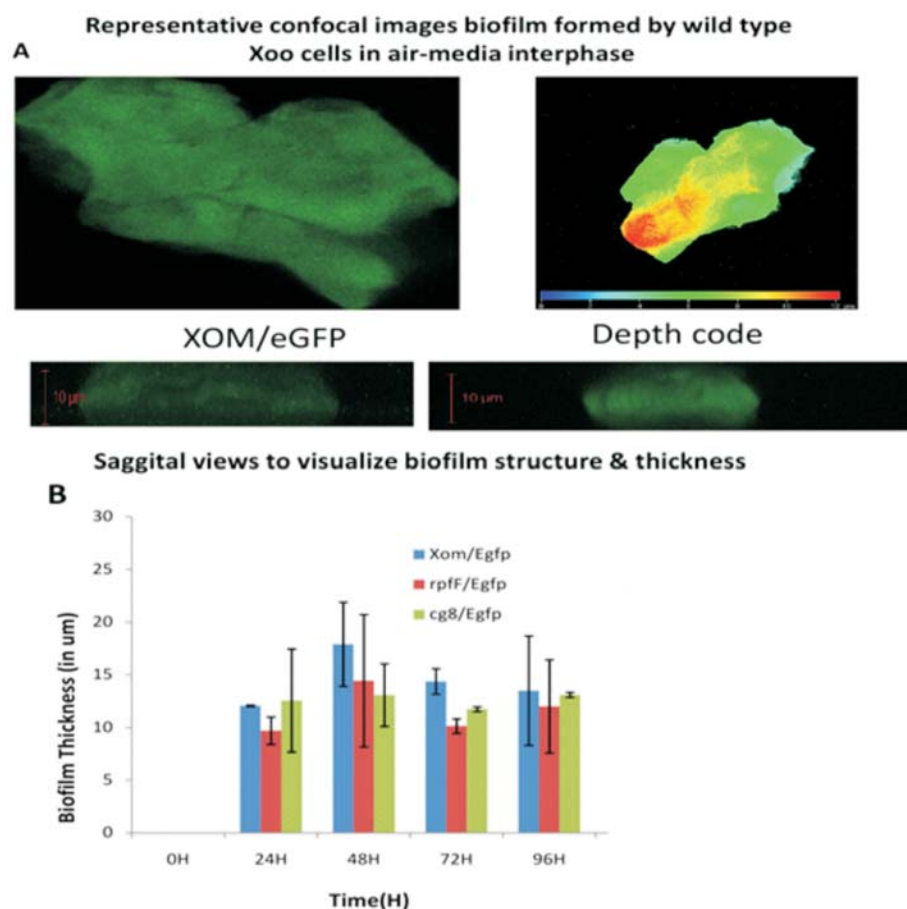


Fig. 10.8: A. Representative confocal images of Xoo biofilm formation on air-media inter phase on a glass slide. B. Average thickness of the biofilm formed by different strains of Xoo at different time points measured by confocal microscopy.

of terpene synthase (TPS) or prenyl transferase (PT) proteins in plants using Profile Hidden Markov Model. Efforts are underway to predict the product specificity of the newly identified TPSs through modeling and structure analyses. In the genome analysis programme, work was carried out for understanding within the chickpea. For this, deep sequencing is being done using various next generation sequencing platforms. The 454 pyrosequencing platform generated 8.53 Gb (27 million reads, 11.5X) of sequence data. Sequencing of 3 kb and 20 kb paired-end libraries generated 1.34 Gb and 199 Mb sequences, respectively. Assembly of this data along with other data generated 492 Mb (66% of the genome) assembled sequence. The *de novo* assembly and characterization of the chickpea transcriptome revealed a total of 34,760 transcripts. The information on genome and transcriptome is helpful in the identification of genetic markers. In chickpea, interspecific linkage map has been constructed for ICCV-2 x JG-62 using 522 STMS markers, and for ICC4958 x PI489777 using 735 EST based markers along with 278 genomic STMS markers.

In the Indo-Canadian Pulse Genomics Initiative, a total of 536 SSR primers were designed from lentil, of which 196 were validated. In another legume *Trifolium*

alexandrinum, a microsatellite enriched library was constructed which led to the development of 692 SSR markers. In the case of foxtail millet, 98 novel ILP markers were developed using sequence information of rice. For periwinkle, a map of 8 linkage groups spanning 1790.4 cM and mean distance between 172 markers of 10.34 cM has been prepared. In order to gain functional and biological insights from the vastly growing plant genomic data, efforts were made to identify microsatellites (or SSR sequences) in available plant genomes using the Mreps algorithm combined with customized perl scripts.

The understanding of the molecular mechanisms of abiotic stress responses has improved. In rice, different experiments revealed interactions of stress associated protein, OsSAP1, with OsRLCK253 and OsSAP11 in the plasma membrane and nucleus, respectively, and interaction of OsSAP11 with OsRLCK253 at the nuclear and plasma membranes. Also, transcripts of several transcription factors were found to be up-regulated during water-deficit and high salinity stress conditions. Few of them, including two belonging to homeobox family, are being investigated for their function. An interactome map between OsMPKs (MAP kinases) and OsMKKs (MAP kinase kinase) was generated. It was observed that in rice, induction of

phytoalexin biosynthesis genes by UV-B rays was linked with the activation of MAP kinase. Study with a core set of foxtail millet cultivars suggested that drought tolerant cultivars possess a wider array of antioxidant machinery with an efficient ascorbate-glutathione pathway. cDNAs coding for putative dehydration responsive element binding protein, *SiDREB2*, and a salt-stress related NAC protein, *SiNAC*, were characterized from foxtail millet. Using heterologous systems, it was shown that CaZF, a C2H2 zinc finger protein from chickpea, improved salt stress tolerance in yeast and tobacco. The transgenic tobacco lines overexpressing CaZF produced phenotypes like improved root and shoot growth along with stress tolerance. Two stress-inducible promoters were also evaluated for their activity and raising transgenics with selected target genes.

In the nutritional genomics programme, with the objective to increase the shelf life of fruits and vegetables, the N-glycan processing enzymes α -D-mannosidase and α -hexosaminidase were silenced to decrease and delay the fruit softening in tomato and capsicum. In an effort to increase the nutritional value of crops, stable lines of AmA1 potato developed were grown and evaluated. The transgenic potatoes have increased protein content and are safe for consumption. Oxalate is a major factor in

urinary tract calculi, hyperoxaluria, hypocalcemia, and nephrolithiasis. The *OXDC* gene encoding oxalate decarboxylase from wood-rotting fungus *Flammulina velutipes* was introduced into tomato, spinach, and soybean to reduce their oxalate content. The transgenic grasspea over-expressing *OXDC* gene, to make it edible by reducing the associated neurotoxin risk factor, has been raised. Few important glucosinolate biosynthesis genes like *MYB28*, *CYP83A1*, and *GSL-ELONG* were isolated and characterized from *Brassica juncea* with the ultimate objective of reducing glucosinolate content.

In the field of plant development and architecture, NIPGR has contributed significantly. Investigation of Z-box specific transcription factors in light signaling pathways revealed that ZBF2/GBF1 is a negative regulator in light mediated inhibition of hypocotyl elongation, whereas HY5 positively regulates photomorphogenic growth in various wavelengths of light. Experiments designed to study crosstalk between different plant hormone responses suggested that brassinosteroid induced randomized growth of dark-grown seedling hypocotyls was facilitated by auxin and antagonized by ethylene. Glucose was found to affect most of the important genes involved in cytokinin biosynthesis, perception and signaling. In rice, functional

analyses of seed-specific genes and anther-specific gene promoters are going on with a view to understand the crucial controls of reproductive development connected to the yield. For the first time, in *Pisum sativum*, details of the structure and function of stipules were explored and it was found that the stipules share anatomical features of leaves but have better hydraulics. In *Arabidopsis*, it was found that tasiRNAs might be regulating root architecture by modulating different ARFs and some miRNAs.

Microarray analysis on differential transcriptome of chickpea-*Fusarium* interaction was performed, and a gene regulatory network specific to disease vs. immune pathway was constructed. To understand the early responses elicited by chickpea blight fungus *Ascochyta rabiei*, PCR based suppression subtractive hybridization (SSH) strategy was used to isolate early responsive genes of chickpea. In *A. rabiei*, analyses of differential expression of several genes after oxidative stress treatment led to the cloning and characterization of *OYE*, *AOX* and *YAP1* genes. In soybean, it was demonstrated that the resistance against MYMIV was due to an enhanced viral origin of replication-specific siRNA accumulation and DNA methylation.

During the period of report, NIPGR researchers published 61 high impact

papers. In the same period, three patents were filed and two technologies developed at the Institute were transferred for product development. A Plant Growth Facility has also been activated. The research programmes at NIPGR are aimed to improve the yield and quality along with protection of loss due to stress. The ongoing activities at NIPGR will contribute significantly to achieve these objectives. The Institute is now looking forward towards new horizons in the field of Translational Research, Plant development & Nutrition and Seed Biology.

Institute of Life Sciences (ILS)

The institute continued research on three areas centered around infectious diseases biology, gene function as well as regulation and translational research through technology development.

Infectious disease biology: Work on identification and characterization of an immunoregulatory helminth glycoprotein was taken to its logical end. The active moiety that binds to TLR4 on the surface of mononuclear cells and inhibits endotoxemia in animals was identified to be a hexasaccharide, Chitohexose (Fig 10.9). This also offered insights into evolutionary relationship between nematodes and sepsis in human population. The research on TLR

polymorphism in human filariasis revealed an association of TLR2 mutants (ins/ del + del/ del) and minor allele (del) for increased risk of elephantiasis development.

These findings shed light on the molecular efficiencies of pathogenic isolates of *V. cholerae* harbouring natural variants of ctxB in causing the disease, suggesting the need to consider ctxB variants in designing

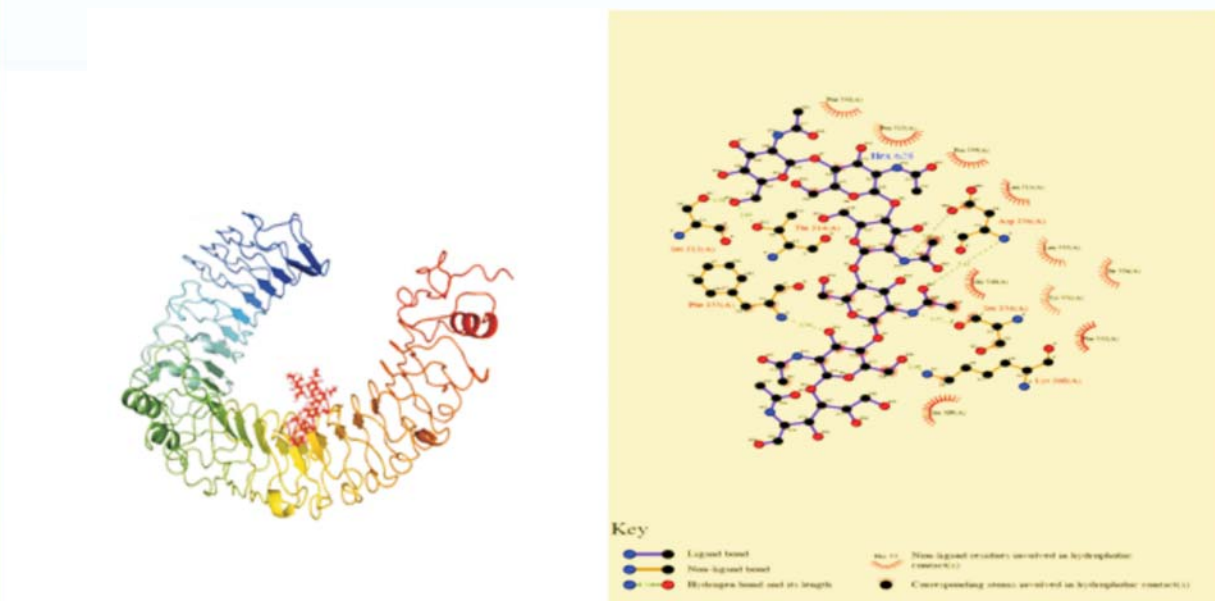


Fig 10.9: *In silico* analysis of interaction between ctxB and TLR4- three dimensional molecular docking between ctxB and extra cellular domain of mouse TLR 4 was performed using patch dock software demonstrating the interaction of ctxB to the internal pocket of extra cellular domain of TLR4.

Studies undertaken on pathogen vibrio isolates have revealed details of genes regulating toxicity and virulence and ability to form biofilms. Molecular analysis of toxigenic *V. cholerae* strains indicated the presence of multiple ctxB genotypes. The comparative modelling approach to define the structural features of all known variants of ctxB found in *V. cholerae* including 0139 serotypes suggested subtle variations in the binding ability of ctxB variants to carbohydrate ligands of GM1 viz. galactose, sialic acid and N-acetyl galactosamine.

vaccines against cholera.

Gene regulation and function:

To understand the progression of cancers in general and Chronic Myeloid Leukemia in particular attempts were made with newer technologies and discoveries such as micro RNA to understand the role of miRNA in CML cases both during blast crisis and in chronic phase. The studies on consequences of post translational modification (acetylation) of the proto

oncogene EVI1 in case of CML revealed that EVI1 binds to SIRT1 promoter element and up regulates SIRT1 transactivity which triggers deacetylation and degradation of EVI1 and in term can regulate p53 activity. Metagenomics is evolving into a promising area of research along with bioprospecting of extremophilic bacteria. Several novel extremophilic organisms have been isolated and identified at ILS. Characterization of their house keeping genes and their expression in plant systems are expected offer interesting opportunities.

Work was pursued at ILS towards generation of transgenic plants with catalase-antioxidant enzyme that significantly contributes to plant growth, survival and crop yield. In order to obtain a proof of principle for the above, transgenic Arabidopsis plants with mutant Catalase gene have been generated. Moving this approach to Rice plant will be the natural step forward. Another potential way to make plants resist pest will be to enhance their innate immunity. Introduction of genes of innate immunity of higher organisms such as human or murine defensins into plants using high expression promoters is another issue being pursued. Generation of several plant promoters by DNA shuffling has been a major activity in ILS in this direction. The spinoff from this study is the possible use of plant extracts

expressing antibacterial peptides as dressing material for wound healing and burns. A third approach is to acquire insights into genes that are associated with development of tolerance to abiotic stress such as high salts by cloning and sequencing ESTs of several genes using *S.maritima* as a model plant.

Translational research and Technology Development

Nano targeting of Gemcitabine the drug of choice for pancreatic cancer is being attempted in a xenotransplant model in SCID mice and early results have shown promise. The next logical step will be undertaking clinical trial for pancreatic cancer which has a very poor prognosis. Significant progress have also been made in the synthesis of amphiphilic polymer coated MNPs which provides the platform for in vitro as well as in vivo studies of drug delivery into brain in case of brain tumor and or cancer.

Institute of Bioresources and Sustainable Development (IBSD), Imphal

Institute of Bio-resources and Sustainable Development (IBSD), Imphal has continued its efforts on sustainable utilization of bioresources focusing on medicinal,

aromatic and horticultural plants, microbial, aquatic and insect bioresources toward economic development of North East Region. Significant achievements during the year are summarized below:

Medicinal, Aromatic and Horticultural Plant Resources

Petroleum ether extract of *Oroxylum indicum* was found to exhibit high level of cytotoxic effect and apoptosis on Hela cells. Germplasm repository of Zingiberales has been further enriched by addition of 27 more species raising the collection to 289 accessions belonging to 73 species. *Bambusa manipureana* and *Dendrocalamus hamiltoni* have been selected as superior edible bamboo due to their low cynogenic glycosides content, high antioxidant properties and high level of nutrient content. Kachai lemon found as a potential root stock for production of budded mandarin orange, to increase yield, reduce moisture stress and *Phytophthora* disease incidence.

Microbial Resources

A strain of *Bacillus subtilis* MTCC 548 from fermented soybean was found to exhibit very high fibrinolytic casenolytic ratio indicating high affinity to fibrin. Production, extraction and purification process of four

such novel fibrinolytic enzyme were also carried out. A total of 1857 bacterial strains from NE region soil have been found to exhibit anti-cancer, anti-diabetic and anti-inflammatory property. About 100 cellulolytic isolates across six sites of NE region, high level of cellulase activity (3.815 µg/ml/min) was detected in their culture filtrates. A microalgae repository with over 2000 isolates has been established at the institute. Two isolates of *Enterobacter* sp have been found to stimulate seed germination and seedling growth in mandarin orange. Bio-pesticide formulations comprising *Trichoderma* sp T-86 and *Pseudomonas* fluorescent IE 161 strains has been tested at field level for the control of soft rot disease in ginger.

Aquatic and Insect Bioresources

Seed production technology of two indigenous ornamental fishes developed and formulated low cost feed using Rice bran: mustard cake: silkworm pupae waste with different proportions shown promising results.

Bio-resource Database Unit

Two software programs (SSRIST-for analysis of Simple sequence Repeats, GLogo-genome sequence logo representation) developed. Databases on Zingiberaceae,

North-Eastern Human Resources, Bamboo and Orchids have been updated.

Human Resources Development

Currently, 16 Ph.D. - JRFs, 7 Post-doctoral fellows and 40 project staffs are working at the institute. A total of 30 trainees from different institutes of NE region have been imparted training in various areas.

Regional Centre of IBSD in Sikkim

Germplasm of various medicinal plants and large cardamom (*Amomum subulatum*) collected from different locations of Sikkim Himalayas maintained in the Centre. Further work on ginsenoside biosynthetic pathway, marker development and cell cultures of Panax is in progress. Strain of Colletotrichum gloeosporioides, the fungal blight pathogen of large cardamom isolated in pure form. 28 actinomycetes and 61 indigenous bacterial isolates have been isolated from rhizosphere soil of large cardamom plants.

Outreach programme

A low cost technique for conversion of floating aquatic biomass of Loktak Lake into compost demonstrated to farming community of Bishnupur district. A Training-cum-Demonstration Programme on fermented soybean production technology

using IBSD starter cultures organized in collaboration with Krishi Vigyan Kendra, Imphal.

Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram

The major emphasis of the RGCB is on research programs looking at the Disease Biology and Molecular Medicine. Employing cutting edge technologies, they explore the biological systems with a mission to understand the diseases processes focusing on cancer, infectious diseases, neuronal disorders, reproductive and cardiovascular diseases. The ultimate aim is to understand the molecular mechanisms, facilitating development of novel diagnostics and therapeutics. Equal emphasis is given to understand the host-pathogen interactions in spices to develop sustainable method to improve product quality.

Disease Biology Center of Diabetes: RGCB began a new program in disease biology of diabetes by taking up the management of the Institute of Diabetes, a specialty medical center belonging to the Government of Kerala. This will allow RGCB access to well-established facilities that will eventually form the nucleus of an advanced center for chronic disease biology.

Drug-induced Senescence Generates Chemoresistant Stem-like Cells with Low Reactive Oxygen Species

A study provides evidence for the rare escape of tumor cells from drug-induced cell death, after an intermediate stay in a non-cycling senescent stage followed by unstable multiplication characterized by spontaneous cell death. However, some cells appear to escape and generate stable colonies with an aggressive tumor stem cell-like phenotype. These cells displayed higher CD133 and Oct-4 expression. Notably, the drug-selected cells that contained low levels of reactive oxygen species (ROS) also showed an increase in antioxidant enzymes. Consistent with this *in vitro* experimental data, RGCB scientists observed lower levels of ROS in breast tumors obtained after neoadjuvant chemotherapy compared with samples that did not receive preoperative chemotherapy. These latter tissues also expressed enhanced levels of ROS defenses with enhanced expression of superoxide dismutase. Higher levels of Oct-4 and CD133 were also observed in tumors obtained after neoadjuvant chemotherapy. Further studies provided evidence for the stabilization of Nrf2 due to reduced 26 S proteasome activity and increased p21 association as the driving signaling event that contributes to the transition from a high ROS quiescent

state to a low ROS proliferating stage in drug-induced tumor stem cell enrichment.

Differential gene expression in breast tumor tissue at different stages of menstrual cycle: Special emphasis on timing of breast cancer surgery and prognosis

Apprehensions are high that dispersal of tumor cells to the other parts of the body during a breast surgery depends on the phase of menstrual cycle the patient is in. If genes involved in various aspects of carcinogenesis are hormonally regulated, modulation of their expression at specific phases of the menstrual cycle might predispose seeding of cancer cells towards faster growth rate or of increased metastatic potential. The scientists at RGCB are aiming to understand at the gene level, if timing of surgery during a particular phase of the menstrual cycle plays a significant role in survival of a pre-menopausal woman with breast cancer finding important molecular events/ patterns that occur might help to determine a long term prognosis by appropriately timing the surgery and hence save lives. By Microarray studies, a number of genes which had protective effect were up regulated in luteal phase with respect to that in the follicular phase. Some of the significant ones include CDH: (a gene involved in cell adhesion was up regulated

by 4 fold), ING1: (a tumor suppressor that induces cell growth arrest and apoptosis was up regulated by 6 fold), KRT8: (a gene known to maintain cell integrity and cell differentiation was up regulated by 2 fold), CST6: (with an anti-metastatic function was found to be up regulated by 3.4 fold). Genes which are normally expressed in during tumor progression such as MUC-1, VIM, CTSD, and CTSB were notably downregulated.

Proteomic analysis of circulating cells for the discovery of biomarkers of increased risk of atherosclerosis in patients with type 2 diabetes mellitus

Endothelial dysfunction, diabetic dyslipidemia, hypercoagulability, impaired fibrinolysis, platelet hyperaggregability, oxidative stress, autonomic neuropathy, toxic effects of hyperglycemia all contribute to the mechanisms of increased risk of atherosclerosis in Type 2 diabetes. Hyperglycaemia may induce a chronic inflammatory state in the vessel wall, thus accelerating the development of macrovascular complications. It is speculated that the circulating monocytes may secrete specific proteins that could serve as individual markers or define a characteristic profile. Changes in the normal physiology of proteins that are relevant to atherogenesis, may promote atherosclerosis in patients with type 2 diabetes. Scientists

have identified a secretory factor, Cyclophilin A, a peptidyl prolyl cis trans isomerase in monocytic cells of THP-1 cells as well as from patients with Type 2 Diabetes Mellitus which is released by monocytes in response to oxidative stress induced by hyperglycemia. Cyclophilin A (CyPA) is known to have paracrine and autocrine stimulatory effect on endothelial cells. CyPA secreted by monocytes could have important effects on enhancing monocyte adhesion to endothelial cells and thus in the pathogenesis of atherosclerosis in type 2 diabetes.

Molecular Typing of local isolates of Chikungunya Virus: Identification of mutant strains with potential for transovarian transmission in mosquitoes

A number of novel mutations, in both structural and non-structural protein coding regions, were identified in CHIKV isolates between 2006 and 2008 from Kerala by whole genome sequence analysis. Subsequently, these strains were identified to have varying levels *in vitro* infectivity in cell lines originated from different tissues. While studying a CHIKV outbreak in 2009 in Northern Kerala, RGCB scientists identified a novel strain of the virus with specific mutations in the E2 protein (L210Q). It could detect the possibility of trans-ovarian transmission of this virus strain in mosquitoes. This observation, was

subsequently supported from studies in other laboratories, can have significant epidemiological implications during CHIKV outbreaks. Recently, they have expressed and purified the recombinant envelope proteins E1 and E2 from local CHIKV isolates for diagnostics development and for use in studies on viral pathogenesis. The institute is also providing service facilities of excellence for molecular Diagnostics for infectious diseases, cancer and cardiovascular disease, DNA Fingerprinting to cater to social & criminal justice systems and DNA Barcoding for Plants and Wildlife

NEW INSTITUTIONS/CENTRES

Institute of Stem Cell Biology and Regenerative Medicine (InStem), Bangalore

The objective of the institute is to build a strong foundation for core research and educational activities in the area of stem cell biology and regeneration. Various activities undertaken include:

Basic Biology

This core scientific program was initiated with the appreciation that understanding stem cell functions will require fundamental investigations into basic, molecular and

cellular processes. Several projects are being pursued collaboratively. They are: a) Protein-protein interactions b) Quiescence and cell cycle c) Signaling pathways d) Embryonic stem (ES) cell self-renewal e) RNA biology f) Chromatin biology and regulatory networks.

Model Systems

Lower organisms can regenerate their entire body, a property that is lost in higher animals including humans. If they can understand the cellular and molecular basis for the regenerative capacity of these model organisms such as Hydra and Planaria, they may be able to use this knowledge in two ways: i) to develop methods for augmenting the limited regenerative ability of human tissues/organs; ii) to screen for drugs/small molecules that will assist research and therapy in regeneration; iii) Cardiac hypertrophy & induced pluripotent stem (iPS) cell core: In this program, core InStem scientists are collaborating with scientists and clinicians internationally and within India to work on cardiac function, iPS technology, biophysics and cell biology to tackle a core problem-generating cellular models of cardiac disease; iv) Epithelial biology and molecular oncology: The focus of the team is on epithelial stem cells and development, mechanisms of tumor

formation and networks that control signaling and adhesion in tissue architecture.

Research Infrastructure

The research infrastructure at inStem is being established gradually and by mid 2012, their new space will be ready with clean rooms for ESC, iPSCs, adult stem cell culture, model organism labs & state of the art molecular and cell biology facilities, including office space for 10 PIs.

New research groups

An active recruitment process has resulted in hiring of two outstanding researchers who will build groups in basic biology of stem cells.

Collaborative Science Chairs

Collaborative Science Chairs are accomplished leaders in their field of research, and have permanent faculty positions in a foreign institution. They are committed to working on collaborative projects with scientists at InStem which extend the scope of the host laboratories significantly. This program permits inStem to attract senior leading scientists to the environment for a collaborative engagement that covers

MOUs signed, joint programs

The MOUs and joint programs have been signed with California Institute for Regenerative Medicine, California; Cambridge University and NCBS for joint research interactions; FIRC Institute of Molecular Oncology in Milan for joint research laboratory at InStem; iCeMS, Kyoto for joint research laboratory at InStem and Stempeutics for research in mesenchymal stem cells.

Integration of CMC-DBT Center for Stem Cell Research at CMC, Vellore

CMC-DBT Center for Stem Cell Research (CSCR) was established in 2005 as collaboration between DBT and CMC Vellore. Now this Centre has been integrated with inStem as its translational unit through a MoU. inStem and CSCR will work closely on various aspects of stem cell and regenerative medicine.

Centre for Molecular Medicine (IFoM)

InStem have recently entered into an agreement with the FIRC Institute of Molecular Oncology in Milan for a new venture on cancer research. Co-funded by both institutions, the collaboration will be effected by an inStem-IFOM Joint Research Laboratory at inStem. Research fields of particular interest for the Laboratory include

cancer epigenetics, stem cell research, chromatin dynamics, virology and computational biology. Recruitment of a group leader to this program will be undertaken via a joint process.

Translational Health Science and Technology Institute (THSTI), Gurgaon

THSTI is an autonomous institution established by the Department of Biotechnology. The institute is designed to be a dynamic and interactive organization with a mission to conduct innovative translational research and develop research collaborations across disciplines and professions to accelerate the development of concepts into tangible products to improve human health. The institute presently focusses research activities in three broad areas, for which three centres have been established namely, (i) vaccine and infectious diseases centre, (ii) paediatric biology centre, and (iii) centre for bio design and diagnostics development. A Clinical Development Services Agency (CDSA) has been established as an extra-mural Centre of THSTI.

Vaccine and Infectious Disease Research Centre (VIDRC)

VIDRC conducts basic and clinical research to advance translatable knowledge to

develop novel vaccines and biologics. Under the vaccine development program, phase III trial of an oral rotavirus vaccine 116E is carrying out at VIDRC. Research programme pursued developing a novel vaccine delivery vectors. THSTI and IAVI have entered in to a collaboration agreement focussing on a cross section study to screen for and generate broadly neutralizing monoclonal antibodies from HIV infected individual. The centre is also focussing on development of animal models, and understanding the natural history of disease in population giving new insights into protective host responses and biomarker discovery for screening vaccine candidates.

Paediatric Biology Centre (PBC)

This centre is undertaking studies on human perinatal biology including maternal, fetal, neonatal and childhood infections, nutritional biology and other childhood illness. The research activities have been developed as domain programs in immunobiology of perinatal period, the biology of vaccine immunogenicity in Indian infants, molecular biology of specific paediatric diseases and innovative technologies for newborn and child health. The core research programme is focusing on immunological characterisation of leucocytes in human cord blood and early

infancy. Work on evaluating the ability of novel safe adjuvants like Vitamin D to enhance the quality and duration of systemic immune responses to antigens including the Inactivated Polio Virus (IPV) vaccine and its ability to generate priming at mucosal sites to cutaneously delivered vaccines was carried out. A multicentre study has been initiated to develop a rapid diagnostic test for diagnosis of celiac disease (CD) by ICGEB, AIIMS and an industrial partner and the patent for the diagnostic kit has been filed.

Centre for Bio Design (CBD)

CBD centre is engaged in creating medical technology innovation in India for affordable health care and to support services that extend from strategic bench work to commercialization and emphasis is given on development of low cost, high quality indigenous implants and devices. CBD has initiated development of a technology platform for efficient and fast generation of specific antibodies for various antigens.

Clinical Development Services Agency (CDSA)

CDSA is established as an extra mural unit of THSTI to develop a cadre of investigators of global standard in

regulatory product evaluations through a comprehensive and sustained training program. It proposes to establish a network of institutions by supporting good existing centres and upgrade them as centres of excellence (COE) for training and regulatory trials as affiliates of CDSA. It will enter into collaborative agreements with at least five premier institutions in the first year to convert them into centres of excellence to tap the huge potential of the clinical trials market. CDSA will provide a core grant to these institutions to develop human resource and infrastructure. CDSA has been interacting with national and international experts and institutions involved in conduct of clinical trials to develop the most appropriate training strategy. An alliance has been formed among Departments of Health Research (DHR), Department of Biotechnology (DBT), and Ministry of Health and Family Welfare of the Government of India to support research to generate evidence for development of practical and scalable regimens to medically rehabilitate children suffering from Severe Acute Malnutrition (SAM) without serious complications at home/community level and/or at peripheral inpatient facilities. DBT and CDSA have taken an effort to promote use of zinc supplement for the treatment of childhood diarrhea.

National Institute of Biomedical Genomics (NIBMG), Kalyani, West Bengal

NIBMG was established in 2009 to provide an impetus to research and translation to enable an understanding of the aetiologies, prevention and treatment of diseases and a reduction in public health burden of our country. Inadequacy of formal training programmes in human genetics has been a serious impediment to the development of biomedical genetics in our country. NIBMG is likely to be filled by initiating courses on genetics in medicine.

NIBMG has been able to recruit the faculty and strengthen the facility. Two DBT-NIBMG Fellows under Ramalingaswamy Fellows, four Young Biotechnologist Awardees, and one Clinical Research Associate have joined. The faculty members are currently engaged in research, training and outreach programmes of the Institute. Three core areas are developing in NIBMG – cancer genomics; genomics of common diseases and traits, including susceptibility to infections; and, statistical and population genomics. The Institute has successfully generated eight competitive extra-mural research grants, including one from the U.S. National Institutes of Health. Through these research projects, NIBMG has developed collaborations with many national and

international institutions, including medical colleges and hospitals. NIBMG's Ph.D. programme is beginning to thrive; the current strength of our research scholars is twelve and is growing.

The Institute has established a high-throughput DNA sequencing facility that includes six next-generation DNA sequencers and a 96-capillary sequencer. A cell-biology laboratory has also been established. The Institute's flagship project, the International Cancer Genome Consortium – India Project, is progressing well. This project attempts to identify genomic alterations that cause gingivo-buccal oral cancer, which has the highest prevalence in India, using massively-parallel next-generation DNA sequencing technologies.

NIBMG has initiated a major population cohort study in the Kalyani area, to build a long-term cohort of 20000 individuals and serial collection of biospecimens. Training and outreach programmes initiated and conducted several workshops and seminars in the Institute and have had visits by many renowned scientists who have delivered seminars at the Institute.

Construction of campus building on a 30-acre plot of land in Kalyani, has begun and expected to be completed in a period of 2 years.



Fig. 10.10: Professor Terry Speed, Head of Bioinformatics Division, Walter & Eliza Hall Institute of Medical Research, Australia, and a member of NIBMG's International Advisory Board, delivering a talk in the Institute

Regional Centre for Biotechnology (RCB), Gurgaon

RCB is an Institute newly established by the Department of Biotechnology under the auspices of UNESCO. It is envisaged to be an important member Institute of the Biotech Science Cluster (BSC) at Faridabad, NCR where construction activities are under progress. Presently it is undergoing different phases of growth. Currently, the centre is functioning from its interim laboratories at 180, Udyog Vihar, Phase-I, Gurgaon.

Hon'ble Minister, Science and Technology and Earth Sciences introduced a Bill (Item No. 27) during the Winter Session (9th Session of XV Lok Sabha) on 20th December, 2011 to provide for the establishment of an institution of national

importance to be known as the Regional Centre for Biotechnology and Training and Education as Category-II institution under the auspices of UNESCO to undertake research in the field of biotechnology and to provide for matters connected therewith or incidentally thereto.

Regional Centre having the futuristic vision of making biotechnology education, training and research is planned to be within Biotech Science yet broad-based and multi-disciplinary, its proposed research and educational activities being focused to be at the interface of different disciplines of science with Biotechnology as a platform of confluence. The institute is in the process of establishment of the labs and creating infrastructure for research and educational activities. While attempts are being made to establish a wide range of disciplines that include Biomedical Sciences, Bioengineering, Biochemical and Biophysical Sciences, Climate Science, Agriculture and Environment, and Biotechnology Regulatory Affairs, IPR and Policy; a small beginning largely in the area of biomedical sciences has been made with the faculty members recruited.

The structural biology studies of regulatory events in physiological processes focused on immune recognition in the context of antibody pluripotency and structural and

molecular bases in host-pathogen interactions. These studies have led to the elucidation of the structural basis of mimicry of two chemically distinct molecules as seen by the immune system. This shows that plasticity of antigen combining site of the mature antibodies could enable pluripotency even without any structural correlation of the binding antigens. Structural investigations of proteins implicated in pilus assembly and biofilm formation of different bacteria toward understanding bacterial infections and mode of interactions with host are also being pursued.

The molecular mechanisms associated with cell division and intercellular communications including studies on the spindle assembly checkpoint in metaphase, the terminal mitotic process of cytokinesis as well as analyses of the biogenesis and function of tunnelling nanotubes (TNTs) are being studied. Molecular mechanisms in the ubiquitin mediated signaling in cellular pathways with focus being on the deubiquitination events are being explored. Molecular mechanisms of infectious and idiopathic inflammation relating to SUMOylation are being studied using *S Typhi* as a model organism.

Molecular mechanisms of how intravascular hemolysis increases the severity and

occurrence of the thrombotic complications in hemolytic disorders; more specifically, how the binding of cell-free hemoglobin to the plasma protein von Willebrand factor makes them hyperreactive to culminate cell adhesion and clot formation is being addressed. On another front, that links more to the translational research, engineering of nonmaterial for biomedical applications is being pursued.

Currently, seven members of the Faculty including the Executive Director, mainly from biomedical sciences have made their respective laboratories functional. The Centre has been able to attract very smart fresh PhDs for young investigator programme and has started the training of students towards PhD degree. The Young Investigator awardee, the Research Associates, Junior Research Fellows and Trainees programmes have made a beginning with a potential to grow in the times to come

The First meeting of the Programme Advisory Committee was organized on 8th September, 2011 at RCB, Gurgaon under the Chairmanship of Prof K Vijayaraghavan, Director, NCBS, Bangalore. Broad vision of the Centre at the interface of multiple disciplines involving research and education covering diverse aspects of biotech sciences as well as regulatory, IPR and policy issues was discussed at length. An important

recommendation that PAC made was establishing international connectivity by organizing theme-based intense discussion meetings and workshops for enhancing thinning capabilities. Meetings of the Executive Committee, Finance Sub-Committee and Board of Governors were also organized as per the schedule.

National Agri-Food Biotechnology Institute (NABI), Mohali, Punjab

The institute has taken new Initiatives during the year on studying the effect of diet and its constituents on adipogenesis.



Fig. 10.11: Researchers at RCB

Fractionated constituents of selected cereal grains (wheat, finger millet, kodo millet and buck wheat) is being examined in human (preadipocytes/adipocytes) HPAd/HAd and murine (3L3-L1 preadipocytes/adipocytes) cell culture models and *in-vivo* diet-induced obese murine models to study the molecular basis of adipogenesis.

In an another study on targeted mutagenesis for modification of plant genes to design sequence specific zinc finger nucleases (ZFNs), synthetic proteins consisting of an engineered sequence specific zinc finger DNA-binding used to induce double-stranded breaks (DSBs) in specific DNA sequences and thereby promote site-specific recombination and targeted manipulation of genomic loci in a variety of different cell types is being deployed to target for gene modification of targeting novel traits in crop plants and to design arrays, improve targeting efficiencies and eventually to translate the information from model plant

systems to crop species like wheat, legumes and vegetable crops.

Nutrition and Processing Quality of Wheat

Micronutrient and bioavailability enhancement

Iron transport from maternal tissues to endosperm in mature wheat seed using synchrotron radiation

In wheat grains iron is located in outer layer, called bran and is lost substantially during milling and processing. Thus the flour is almost devoid of iron. Understand the bottlenecks which prevent iron translocation from the outer bran layers into the endosperm in cereals, wheat grain with iron-enriched endosperm is of great interest. The study to understand the iron localization and to identify the chemical form in which iron is present in different tissues of seed

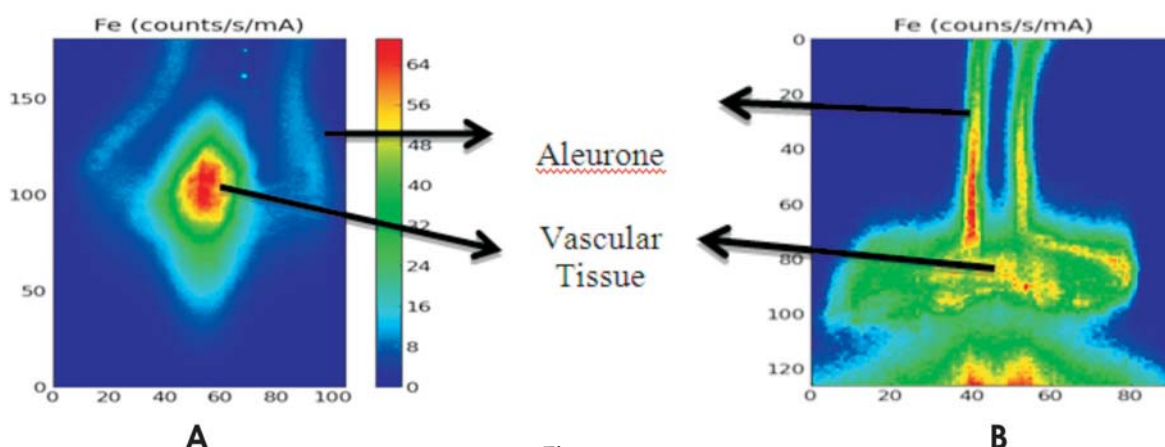


Fig. 10.12

and bottlenecks which prevent iron translocation from the outer bran layers into the endosperm, X-ray Fluorescence (XRF) iron localization maps have been generated in grains of contrasting genotypes of wheat by using synchrotron powered beam line, VESPERS (Very Sensitive Elemental and Structural Probe Employing Radiation), at Canadian Light Source, Saskatoon, Canada. Currently performing, micro-PIXE (Particle induced x-ray emission) iron localization maps to generate and validate the iron in different tissues of seed (Fig. 10.12).

Gene discovery in wheat for improvement of processing quality

Multiplication of wheat germplasm

530 Indian wheat varieties are growing in three replications in RBD as well as augmented design at NABI research farm. 305 exotic and 312 wild wheat lines are maintained in three replicates in RBD design at NABI research farm. These germplasms were grown in this winter season for seed multiplication and nutrition and quality evaluations of a sub-set.

Screening of SSR markers

110 SSR primer pairs were used for screening to select polymorphic primers. Genotyping using SSR primer pairs is being done.

Microarray studies for processing quality

RNA was extracted from four wheat varieties-two good (C306 and Lok1) and two poor chapatti (WH291 and Sonalika) making varieties at three developmental stages-7, 14 and 28 DAA (days after anthesis). The RNA from the four varieties was hybridized to Affymetrix wheat microarray containing 25,000 unigenes. The hybridization data was analyzed and a set of differentially expressed genes were identified between good and poor chapatti varieties. Biochemical analysis of a few differentially expressed genes is being conducted to validate the gene expression data. RNA was extracted from two soft wheat varieties (Naphal & Chinese Spring) and one hard (PBW 343) wheat varieties. The extracted RNA is being used for microarray-based transcript studies.

Database for grain hardness of Indian cultivars

Studies on genes involved in grain hardness e.g. Puroindoline were initiated to find out structure function relationship and involvement of different genes in grain hardness. Several new alleles were detected in the Indian germplasm.

Development of virus induced gene silencing vector for wheat: Virus was detected from the wheat samples collected during 2010 and 2011. The whole genome of virus was sequenced and nucleotide sequence of two clones has been submitted to the GenBank. Phylogenetic analysis by nucleotide sequence of full-length genome of the virus revealed it was a novel mastrevirus (Family *Geminiviridae*) and is being reported from India for the first time. Infectious clone was made and tested for infectivity. Host range was determined by infecting different Indian wheat varieties

which yielded very good and consistent results.

Modifications have been done in viral genome by removing a small stretch of nucleotide (pathogenicity determinant region of the viral genome) and inserting multiple cloning sites (MCS) at the same positions. Visual marker gene phytoene desaturase (PDS) is being cloned in modified VIGS vector and will be followed by making head-to-tail tandem repeat of the modified VIGS vector having PDS gene (Fig. 10.13).

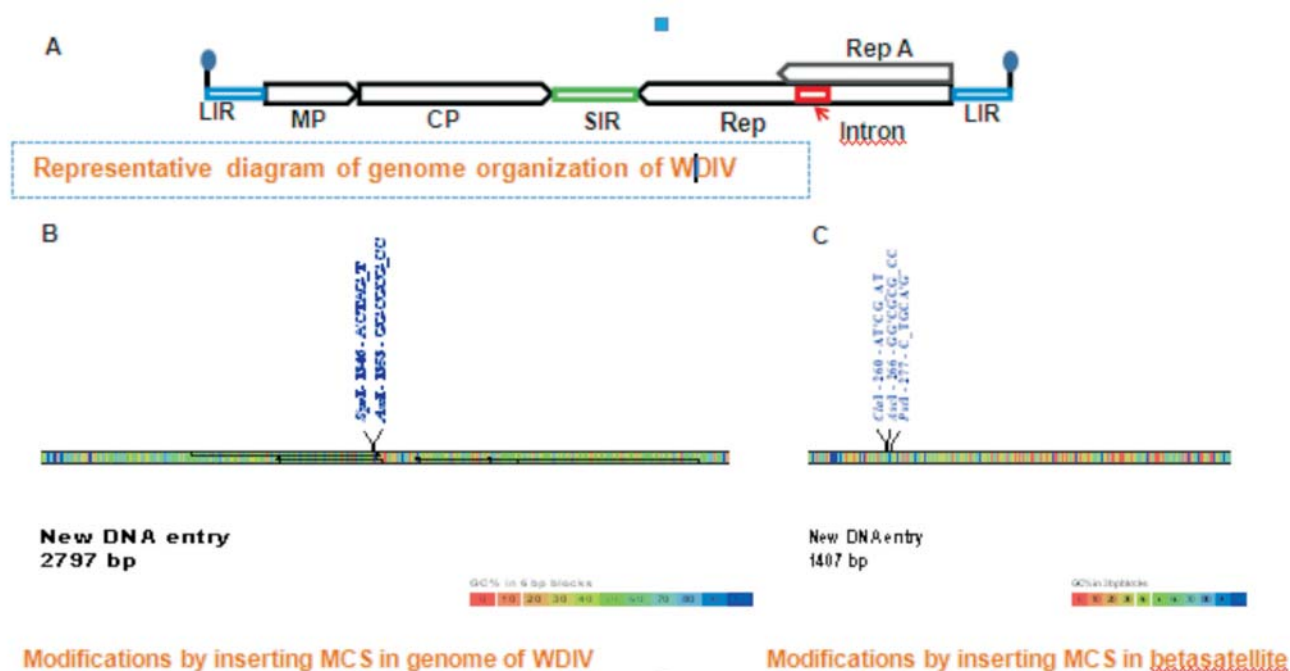


Fig. 10.13: A) Schematic representation of viral genome organization. B, C): modified viral genome and betasatellite having MCS for expression of foreign protein.

Development of viral vector for transient expression

The detected virus is mastrevirus and is known as monopartite geminivirus. Association of betasatellite has been found for the first time with this virus and the same been confirmed by co-infectivity. Result of co-infectivity revealed that the betasatellite played a role of silencing suppressor by suppressing the host silencing machinery which resulted in accumulation of virus in host cell. Since, it is well known that a virus having silencing suppressor can be a good candidate for the expression of foreign proteins in plants and designed oligos to modify the viral genome and betasatellite for the transient expression of proteins (eg. GFP, udi or Zinc finger nuclease protein) of interest in wheat.

Genetic Transformation of Wheat and Banana

Four cultivated varieties of wheat were examined for optimization of regeneration protocol. The embryos from mature seeds were cultured on MS medium containing different combinations and concentrations of growth regulators. Best response for callus induction was observed when embryos were cultured on MS medium supplemented with 2, 4-D and Zeatin. Healthy roots were induced on the MS basal medium (Fig. 10.14

A, B, C, D, E, F). Genetic transformation is being optimized from mature embryos and callus. GUS used as a reporter marker for the transient genetic transformation. Histochemical GUS assays were performed after co-cultivation. Experiments are in progress to develop stable transgenic plants.

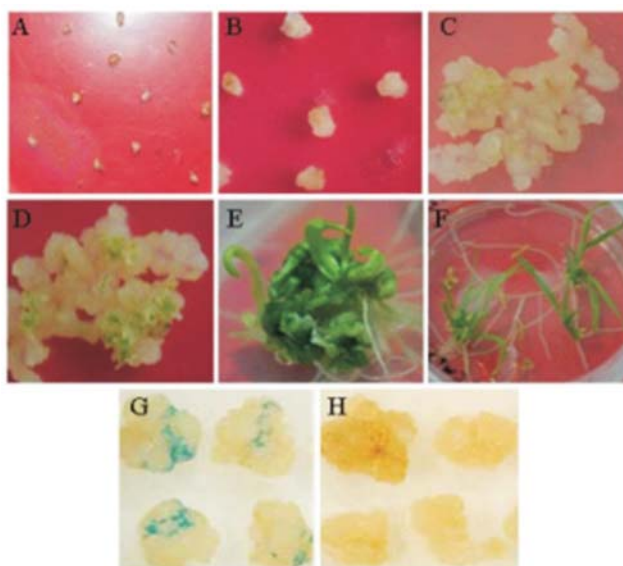


Fig. 10.14: Different stages of *in-vitro* regeneration of wheat plants and stable gene expression. A) Isolation of mature embryos used as explant, B) one month old calli, C) two months old callus, D) and E) shoot induction and elongation, F) root formation G) transient expression of GUS in wheat callus, H) control plants with empty vector.

Accelerated Breeding for processing quality

For improvement of chapatti making quality, good chapatti making old cultivars (C306 and Lok1) were crossed with high yielding recent cultivars (PBW343, PBW550 and PBW621). Crossed seeds were backcrossed at DWR Regional Station, at Dalang Maidan,

Lahaul, Himachal Pradesh in off-season. BC₁ and F₂ seeds have been sown in the field. For improvement of Biscuit making quality, major genes (Puroindoline and HMW Glutenin genes) responsible for grain softness were characterised in the selected lines. For biscuit making quality, wheat landraces (NapHal and IITR67) were crossed with high yielding recent cultivars (PBW343, PBW550 and PBW621). F₁s were backcrossed at Dalang Maidan in off season. BC₁ and F₂ seeds have been sown in field. For bread making quality wild species/genetic stocks of *Ag. elongatum*, *Ae. searsii* and *Ag. intermedium*, are being utilized. Our goal is to transfer HMW-GS genes related to high grain strength from wild species to chromosome 1A of wheat (translocation lines), as chromosome 1A of wheat has some alleles that contribute negatively to bread making quality. .

Establishment of embryogenic suspension culture (ESC) for genetic transformation of

Banana: Immature male flower buds of four cultivars (Grand Nain, Robusta, Nendran and Dwarf Cavendish) were collected from TNAU, Coimbatore. Immature male flower hands of rank 1 to 15 adjacent to the floral apex were isolated and cultured on MS medium containing several combinations and concentrations of different growth regulators for the optimization of protocol. Calli were formed on the callus forming

medium. However, efficiency and response for callus induction depends upon the cultivars. Grand Nain cultivar showed best response for callus formation. Optimization of ESC development has been initiated for the induction of embryos and genetic transformation.

Quality and post-harvest stability of farm produce

The research program on quality enhancement and improving postharvest stability of fruits is focused on understanding biological basis of produce quality and generating basic knowledge to assist genetic and molecular manipulations for better quality traits. The research work has been initiated on mango and litchi fruits during the period under report.

Mango: Research activities were carried out to characterise the aroma-volatiles profiles of mango fruit and to optimise method for rapid assessment of these compounds for developing biomarkers linked to fruit quality and postharvest status. Static headspace (SHS) method was optimised for extraction of aroma volatiles and its efficacy was compared with the widely used solid-phase micro extraction technique. The improved SHS extraction technique was combined with separation on different types of columns (polar and non-polar) and

simultaneous detection using flame ionization detector and mass spectrometer to achieve better resolution and detection of maximum number of compounds.

Litchi: Skin colouration in litchi is due to the presence of anthocyanin pigments whose biosynthesis and postharvest stability can seriously affect fruit quality. To develop better understanding of anthocyanin biosynthesis at molecular level, litchi fruit (cvs. 'Calcuttia', 'Dehradun' and 'Seedless') sampled at different stages of maturation (green, colour break/pink, and red) were subjected to metabolic profiling and fingerprinting. Targeted and untargeted analysis of metabolites from litchi aril and pulp has been carried out to give insights into dynamics of the metabolites in relation to fruit maturation and ripening.

Developmental Biology for Crop Improvement

Identification of genes responsible for seedlessness in *Annona* fruits

Seedlessness increases fruit acceptance by consumers due to several benefits: seedless fruits are easier to eat and fruit processing is easier. Also, seeds have bitter taste and in some instances, accumulate toxic

compounds. In *Annona*, flowers comprise of a cluster of stamens (more than 200) and carpels (more than 100). Each carpel has a single anatropous ovule that may develop into a single seed. The *Annona* fruit develops from the cluster of fertilized carpels, thus the aggregate fruit contains several fruitlets. Out of the multiple fruitlets a few fruitlets develop naturally, without seeds. The aim of the project is to understand the molecular basis of the development of seeded and seedless fruitlets in the same fruit of *Annona* sp. Total RNA has been extracted from developing fruits of *Annona squamosa*, *Annona chermola*, *Annona atemoya*. Anatomical differences between seeded and seedless fruitlets during early stages of development have been identified. Total RNA has been extracted from developed and aborted seed of *Annona squamosa*.

Development of approaches for the modulation of seedlessness, in the scion through rootstock signaling

The research project anticipates establishment of a technology which can lead to the development of a new approach to use transgenic rootstocks for delivering specific siRNAs in non-transgenic scions for the modification of economically important traits. We are currently examining if siRNA based signalling can be applied to develop

rootstocks which may influence seed development in the scion, grafted on to the stock using the model plant *Arabidopsis thaliana*. Developed transgenic lines constitutively expressing GUS reporter gene. Transgenic lines expressing double stranded RNA- hairpin homologue of the reporter gene and target genes involved in seed development have been raised.

Development of Genomic Resources for Grain Crops

Genomic sequence data holds the promise of dramatically advancing the understanding of basic plant science, and of catalyzing practical advances in plant breeding. Genome data of wheat, *Triticum aestivum*, is available in public domain from University of Bristol (5X coverage of genome, ~200 million 454 reads). Genome data of the wild wheat, *Aegilops tauschii*, is recently available from CSHL (Illumina reads). The studies undertaken for genome assembly and analysis to generate framework map of wheat and to identify the vast majority of genes in three closely related progenitor genomes of wheat (AA, AABB, and DD genome containing species) and hexaploid wheat (Chinese Spring). Data from the above resources along with in-house data generated for transcriptomes of different germplasms at NABI will be used

for improving the draft assembly and scaffolding. Identified 90K putative SNPs by comparing inhouse generated transcriptome and publicly available ESTs till date. We are also identifying SNPs for genes expressed differentially on microarray of wheat varieties contrasting for processing traits. Comparative Study of *Triticum monococcum* and *Aegilops tauschii* transcriptome has led to identification of new transcripts after comparing with Unigene database (13620 for *Triticum monococcum* and 9950 for *Aegilops tauschii* new transcripts). Microarray data analysis and meta-profile analysis of wheat expression array for understanding the gene expression dynamics in starch and sucrose metabolism pathway in genotypes with contrasting baking, chapatti making and biscuit making quality for mapping of differentially regulated genes on metabolic pathways is under progress.

Development of genomic resources for horticultural crops

Germplasms collection of fruit crops is in progress. About 35 cultivars of fruits belonging to 16 species have been collected from different parts of India. The list of varieties/wild species collected and planted at NABI research farm is as below:

- *Annona squamosa*, *A. cheimoya*, *A. reticulata*, *A. atemoya* and some selections such as NMK-1, Chandshila, Annona-2.
- Banana: Grand Nain, Robusta, Nendran, Poovan, Rasthali, Red Banana, Ney Poovan, Virupakashi, Karpuravalli, Dwarf Cavendish, Dwarf-Robusta, Udhayam and Nanjanagud-Rasabale
- Mango: Dashehri, Amrapalli, Mallika, Langra, Chausa
- Guava: Allahabad Safeda, Lalit, Lucknow-49, Arka Mridula, Shweta
- Litchi: Calcuttia
- Sapota: Cricket ball, DHF
- Citrus: Kinnow, Baramasi lemon, *Citrus jambhiri*, Jaffa Orange, Star Ruby grapefruit
- Pomegranate: Bhagwa
- Pear: Punjab Beauty, Patharnakh
- Plum: Kala Amritsari, Sutlej Purple
- Aonla: NA-6, 7, 10, Krishna
- Bael: CISH-B1 and B2

Additionally, several germplasms have been collected such as wheat (>1500 lines), rice (16 lines), pearl millet (4 lines), finger millet (5 lines), mung and urd bean (26 lines), sorghum (41 lines) and chickpea (9 lines).

National Institute of Animal Biotechnology (NIAB), Hyderabad

National Institute of Animal Biotechnology (NIAB), a new autonomous institution of

DBT, is being established within the campus of University of Hyderabad, Hyderabad. NIAB has been registered as a society as per the Andhra Pradesh Government Act., 2001 (Act No. 35 of 2001) on 25th May, 2011 and started operating from an interim office building in the campus of University of Hyderabad. To initiate R&D activities NIAB has hired a building very close to the site allotted to NIAB. NIAB has initiated the recruitment process for scientific, technical and administrative positions.

NIAB is designed to harness novel and emerging biotechnologies and take up research in the cutting edge areas for improving animal health and productivity. The Institute's focus of research will be on infectious diseases, breeding, reproduction and nutritional enrichment. The institute aims at translational research leading to the development of novel vaccines, diagnostics and improved therapeutic molecules for farm animals. The Institute plans to promote bio entrepreneurship by providing support to commercial tenants involved in the development of farm animal based products.

BIO-CLUSTERS

Biotech Science Cluster

The Department has established a Biotech Science Cluster at NCR region of Delhi. The

heads of four founding institutions namely, the National Institute of Immunology; the Regional Centre for Biotechnology; the Translational Health Science and Technology Institute and the National Institute for Plant Genome Research have signed a MoU to create a new entity called the Cluster Board. The Cluster Board is an enabling mechanism by which these institutions, while maintaining their own autonomy of governance, can address not only common infrastructural and cluster-related administrative issues but also synergize their complementary intellectual strengths and facilities to create a seamless campus. This Cluster will coordinate the development of the new campus at Faridabad.

Efforts are being made to create this Cluster as a legal entity. A “Centre for Molecular Medicine” has been established at this Cluster. The focus of this Centre is on

infections diseases, cancer, cell therapy and drug design.

Bangalore Bio-cluster

Bangalore Biocluster comprises the National Centre for Biological Sciences (NCBS), the Institute for Stem Cell Biology & Regenerative Medicine (InStem) and Centre for Cellular and Molecular Platforms (C-CAMP). These three institutions are interacting, sharing knowledge and resources on a regular basis to enrich research. C-CAMP is acting as provider, developer and enabler of technology development, scientific activity and entrepreneurship. This is an institutional model for cutting edge scientific research aimed at utilizing various centres of excellence for developing new hubs. InStem is developing collaborating programmes with other institutes utilizing the infrastructure and facilities available in the Cluster.



PUBLIC SECTOR UNDERTAKING

Bharat Immunologicals & Biologicals Corporation Limited, Bulandshahar (BIBCOL)

Bharat Immunologicals and Biologicals Corporation Limited (BIBCOL) was engaged in formulating Oral Polio Vaccine (OPV), located at Bulandshahar, Uttar Pradesh towards eradication of Poliomyelitis in the country through Pulse Polio and routine immunization programmes. As the demand for OPV is in decline phase, BIBCOL added monovalent oral polio vaccine mOPV -1, 2 & 3 in its product portfolio, and efforts are on for introduction of bivalent OPV (1 & 3). In pharmaceutical sector, BIBCOL's Zinc Dispersible Tablet has started gaining a major market share in public sector and a combo kit (Diarrhea Management Kit) for treatment of diarrhea among young children has been introduced in the market. The production has been optimized using the existing resources and reducing the dependency on a single product, by

diversifying into other vaccine and pharmaceuticals related to child health care and marketing is being strengthened.

New initiatives made to strengthen Research & Development and currently working on solutions for treatment of several malnutrition among young children and manufacturing facilities for oral solid doses form is being created for various products. A product sale is expected to touch around Rs. 50 crores during the current year. For successful management of Diarrhea & Malnutrition introduction of dispensable zinc tablets and mineral vitamin mix formulations is taken up.

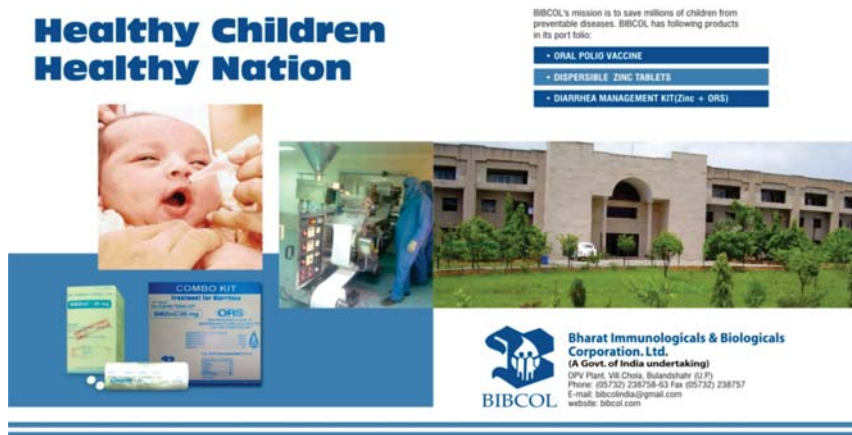


Fig. 11.1: Combo Kit – Treatment for Diarrhea

**Indian Vaccines Corporation
Limited, Gurgaon**

The Indian Vaccines Corporation Limited (IVCOL) was started as a joint venture company in March, 1989 to undertake research and development and manufacture of viral vaccines. Due to change in product mix policy and non-availability of vero cell technology from Pasteur Merieux Serum & Vaccines (PMSV), France, the company was on hold since February, 1992. In pursuance of the Cabinet decision in September, 1998 restructuring process of the company has been undertaken to utilize the assets created under the project. Accordingly, the National Brain Research Centre (NBRC) has been

established as part of IVCOL premises.

Concerted efforts have been made to finalize the restructuring process with new activities. After taking necessary approvals from competent authority the company has signed lease agreement with IPCL/Reliance Lifesciences, one of the promoters of the company, to initiate new activities including production of vaccines, biopharmaceuticals and set up superspeciality hospital to initiate translational research in collaboration with NBRC. In order to initiate proposed activities Reliance Lifesciences (RLS) already finalized the master plan for setting up integrated life science unit alongwith super specialty hospital for neuro and cardio at Manesar, Haryana.



INTERNATIONAL CENTRE FOR GENETIC ENGINEERING AND BIOTECHNOLOGY

International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi has made significant progress in the area of infectious disease, agriculture and bio-energy during the year. Several new initiatives were taken by sourcing funding from different agencies and from Bill Gates Grand Challenge Exploration grant for the second phase of research.

Human Health

Malaria

A recombinant malaria vaccine candidate against *Plasmodium falciparum*, JAIVAC-1, which is composed of two recombinant protein antigens, PfMSP1₁₉ and PfF2, formulated with the adjuvant Montanide ISA 720 was tested in a Phase I clinical trial. This is the first novel recombinant vaccine developed indigenously and tested for the first-time-in human clinical trial in India. JAIVAC-1 was found to be safe and elicited robust antibody responses against PfF2 but poor immune responses against PfMSP1₁₉. A next generation vaccine candidate JAIVAC-2, which contains PfF2 and PfMSP1₁₉-PfMSP3₁₁, has been developed to overcome with the problem of poor

immunogenicity of PfMSP1₁₉ as well as target another merozoite surface protein, PfMSP3.

Programme has been initiated to understand the molecular basis of key mechanisms in the biology of blood stage malaria parasite. The program will undertake novel interdisciplinary approaches using cutting edge technologies to understand key processes involved in intracellular growth, egress and red cell invasion by malaria parasites. Another project initiated to focus study on the molecular epidemiology of malaria in endemic regions of Central India in collaboration with the Regional Medical Research Centre for Tribals (RMRCT), Jabalpur, Madhya Pradesh has been initiated. This project aims to characterize the invasive properties of *P. falciparum* isolates from the field, and to understand naturally acquired immune responses against blood stage parasite antigens and their role in protection against malaria.

Immunology

Several host-factors have been identified that are required by the Mycobacterium for its

survival within host through genome-wide siRNA approach. Subsequently, complete metabolome, lipidome, proteome and transcriptome profile of macrophage cells infected with Mtb are being generated to represent finest details of cellular responses upon infection. A novel protein-kinase centric network regulating overall cellular responses were identified that are now being investigated for their efficacy as potential drug targets against tuberculosis. The group has also discovered a novel role of mesenchymal stem cells in regulating immune responses against Mtb infection.

Under the second phase of 'Centre of Excellence Program on TB Research', it is planned to develop novel intervention strategies for tuberculosis. Under the project funded by a Bill and Melinda Gates Foundation (BMGF: Phase-I) on electronic nose for pulmonary tuberculosis disease identification using breath of TB patients was successfully completed. Initial findings showed promising results which are under further validation. Based on the Phase I research, further funding (Phase-II) was received from BMGF and Canadian Grand Challenge for validating breath based biomarkers for TB in a multicentric longitudinal study.

Virology

The Hepatitis E virus studies attempted to identify the cellular receptor for the virus, and to characterize patient plasma and urine proteomes and metabolomes towards the identification of disease biomarkers and a comprehensive understanding of pathogenesis. The HIV research programme has dealt mainly with understanding the role of small non-coding RNAs or microRNAs in disease pathogenesis. These studies led to the identification of a viral suppressor of RNA interference that functions through a novel mechanism not observed earlier in animal viruses. Gene-expression, microRNA and metabolite signatures have also been characterized in HIV/AIDS patients to serve as biomarkers of disease progression and therapy failure. A novel mechanism mediated by the influenza virus nucleocapsid protein was uncovered that restricts innate immunity in infected cells. Multiplex detection strategies were used to understand the ecology of respiratory viruses in patients and evidence was found for a newly discovered virus in these specimens.

Structural and Computational Biology

The group has recently performed structure determination of dehydroascorbate reductase from *Pennisetum glaucum*, which has guided

to decipher the functional role of this protein in rescuing plant cells from oxidative stresses. In addition, extensive NMR-based metabolomics efforts on human biofluids are on-going in an effort to discover biomarkers of human disease. The group collaborates with malaria group for validation of prediction methods for *Plasmodium* protein annotations. Several new prediction algorithms have been developed in the past year for enhancing annotation of various genomic databases. A new initiative aimed at inhibitor discovery against diseases such as malaria and tuberculosis has been undertaken. The strategy is to identify small molecular inhibitors with anti-pathogen properties and to develop them further. This will be based on high throughput screening technologies and a wider spectrum of drug-like libraries.

Recombinant Gene Products

Novel recombinant designer proteins have been developed as an inexpensive, highly sensitive and a specific diagnostic intermediates for viral infections, like HCV, HIV and Dengue virus. The availability of these high quality diagnostic intermediates to manufacturers of diagnostic kits has reduced production costs significantly and these kits are being manufactured in India and being used in several Asian and African countries. Based on the diagnostic intermediates, a test has been commercialized for the detection of dengue NS1 antigen from all 4 dengue serotypes. In consultation with the Indo-US Vaccine Action Program, the group has created DENV-2 envelope-based virus-like particles (VLPs) and are currently under evaluation.



Fig: 12.1: Dengue DAY 1 Test Kit

Studies have been initiated towards finding potent binders and inhibitors of some selected proteins of DENV-2.

Synthetic Biology and Biofuels

An *E. coli* strain was engineered through manipulation of endogenous pathway that could take-up all the C5 and C6 sugars present in the lignocellulosic biomass and converts them into ethanol at a near theoretical yield. Efforts have been initiated at ICGEB to establish a 'DBT-ICGEB Centre for Advanced Bioenergy Research'. The proposed collaborative centre shall be expanding its activity towards genomic, metagenomic, synthetic and systems biology areas for addressing some of the key issues of biofuel development such as finding efficient cellulolytic enzymes, developing biocatalysts for C5/C6 fermentation, generating advance biofuel molecules, and developing robust algal strain for biodiesel production.

Agricultural Biotechnology

Plant Molecular Biology

Several rice transgenic lines for enhanced tolerance to salinity and drought stress conditions have been generated and validated. Novel stress responsive genes from plants and fungus were cloned and

characterized for their potential use as the candidate genes for genetic transformation using tobacco as the model system. Stress-induced beta-carbonic anhydrase from C4 plant (*Pennisetum glaucum*) has been characterized and a new genome walking method to find out transgene integration loci in transgenic genome has been developed.

The role of RAD54 *in-vitro* geminivirus DNA replication with yeast extract has been established. The tomato transgenic plants expressing the artificial microRNA that target the conserved region of the pre-coat protein of a geminivirus, namely ToLCV have been developed. Few host proteins such as GRF1, MCM2, MCM3 having interaction with Rep protein of MYMIV have been identified. Arabidopsis GRF1 was demonstrated to modulate the replication efficiency of geminiviral DNA. More than 200 known and ~1500 novel rice miRNAs have been identified.

Plant Transformation

Efforts have been continued to express various therapeutically and commercially important biomolecules in tobacco chloroplast. Under the Indo-Finland collaborative project supported by the DBT, PTG group in collaboration with a Group at VTT, Finland has produced D1

antibodies, (ScFv and Fab) in plants at a concentration of ~2-4% of the total soluble protein. Similar approach was used to express ten cellulolytic enzymes in tobacco chloroplasts in collaboration with the University of Pavia, Italy. High throughput transcriptomic and proteomic analyses were used to identify genes involved specifically in the development of cotton fiber under NAIP funded project. This study showed that drought has profound effect on fibre elongation by down-regulating important genes involved in cell wall loosening and expansion process.

Insect Resistance

Investigations were continued for exploring insect genomes for identification of proteins that could be useful as insecticidal agents

and two pro-region peptides that specifically kill neonate larvae of *Helicoverpa armigera* have been identified. By subtractive micro RNA library screening, the group has identified a specific microRNA that regulates expression of chitinase in developing larvae. The entire genome of Sf21 has been sequenced and annotated for the identification of new RNAi factors. The data is being scanned for RNAi pathway components and microRNA identification. In addition, the group has profiled microRNA's in malaria parasite transmitting vector, *Anopheles stephensi* at various stages of maturation of *Plasmodium*. Several unique strains of bacteria were identified from the gut of larvae and adult mosquitoes, which are being modified to be employed as delivery agent for desired genes in the gut.



PROMOTION OF BIOTECHNOLOGY IN THE NORTH EASTERN STATES OF INDIA

The North East Region (NER) of India is abundant with rich biodiversity, mineral, water and forest resources and has been identified as one of the world's biodiversity hotspots in terms of spread across diverse ecosystems with rich genetic resources. It also offers rich biodiversity of floral and faunal elements and provides ample opportunities for furthering economic development of the region. In the region agriculture contributes to ~ 30% of the Net State Domestic Product (NSDP) and ~ 75% of the region's population depends on the same for employment. Hence, agriculture and allied sectors were kept as priority areas for biotechnology based development in the region. In view of these, the Department of Biotechnology has earmarked 10% of its total budget amounting to Rs. 140 crores for the year 2011-12 to promote biotechnology activities in the North Eastern Region of India.

In the year 2009-10, DBT has set up a North Eastern Region-Biotechnology Programme Management Cell (NER-BPMC) through Biotech Consortium India Limited (BCIL) for coordination and monitoring of

biotechnology programmes in the North Eastern States of India as part of DBT's commitment towards the promotion of biotechnology activities in the North Eastern Region. A separate building measuring 2000 sq. ft. area has been hired for the NER-BPMC office. The NER-BPMC office is now functional with the appointment of consultants and project managers. The NER-BPMC is working in close cooperation with DBT and other Government Ministries/ Department/ Agencies at the Central and State level alongwith universities and research institutions for development and implementation of various programmes.

NER-BPMC has initiated a number of activities towards biotech based development of the NER in the following thrust areas:

Integrated Technology/Product Development

Three projects aimed towards Integrated Technology/Product Development have been initiated/ implemented during the year.

Twinning Programme

The Twinning R&D program for NER was initiated in the year 2009-2010 towards developing core competence and core capacity in different areas of biotechnology viz. Health Science, Agricultural Science, Veterinary Science, Pharmaceutical Science, Biomedical Engineering, Bioinformatics, Food and Nutrition, Health Care including alternative medicine, Nanotechnology and Environmental Biotechnology, through joint venture, between two or more institutes, where one of the institute is from North East India. This collaboration is expected to play a crucial role in upgrading the skills

of scientists working in NER. In the year 2011-12, a total of 230 proposals were received, out of which 117 proposals have been approved for funding.

A new project tilted 'Biotechnology led organic farming in the NER' focusing large scale demonstrations of use of bioinputs for organic farming of key high value crops (HVCs) of NER has been launched in September, 2010 for a period 3 years. Three institutions, namely: ICAR-RC, Umiam, Meghalaya, 14 Krishi Vigyan Kendra's (KVKs) of NE zone of ICAR and IBSD, Manipur of DBT are major implementing partners of the project. Till December, 2011,

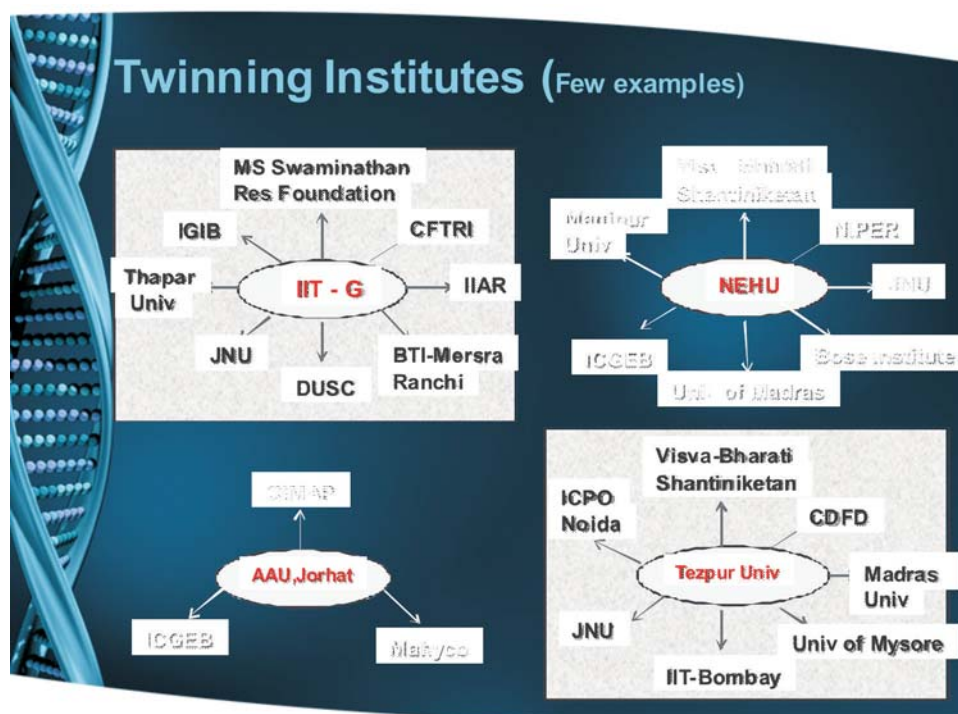


Fig. 13.1: Twinning R&D program for NER



Fig.13.2: Cultivation of Organic Chilli (Bhutjholakia) in Golaghat

project activities like training trainers, farmers and field demonstrations on identified crops established. Brief project achievements are:

- 1400 farmers trained on organic farming technology using bio inputs (biopesticides, biofertilizers, botanicals) for 9 horticultural crops.
- Field demonstrations with organic package in 158 ha already established. First year results from completed field demonstrations are encouraging and profitable.

Biodiversity Conservation & Utilization

During the year, DBT has initiated a research network titled “ Biotech Intervention on Selected Medicinal & Aromatic Plants (MAP) of NER for their effective utilization” on four medicinal & aromatic plants (MAP), launched in October, 2011 involving three partner institutions (a) AAU, Jorhat (Agric.)

(b) AAU, Khanapara (Veterinary Campus and (c) NEIST, Jorhat (CSIR Institute) with the following objective: (a) Taxonomical studies of four MAP Species, (b) Isolation of bioactive phytochemical ingredients of medicinal value, (c) Evaluation of pharmacological activity of bioactive plant extracts /fractions, (d) Assessment of isolated drugs for possible adverse effects on metabolic system, and (e) Development of Good Agricultural Practices (GAP), large scale production of planting material & PHT.

Capacity Building

Key initiatives were taken towards development/upgradation of infrastructure in Medical colleges, establishment of Biotech Hubs, North Eastern Bioinformatics Network (NEBINet), DBT's e-Library Consortia (NER-DeLCON), online human resource repository of Biotechnology and Bioinformatics Resources of North East India

(BABRONE) and development of Digital Database of Bioresource of NE India etc.

Development/upgradation of infrastructure in Medical colleges in North Eastern States of India

The DBT program on Development/Upgradation of Infrastructure in Medical Colleges in the NER was started in the year 2009. The program is now operational in 12 medical colleges/ institutions in four states of the Region, namely Assam, Nagaland, Tripura and Manipur. Labs of 21 Principal Investigators have been renovated/upgraded for carrying out quality research on various health problems prevalent in the region using modern biotechnology tools and technologies. Various scientific equipments including 27 high cost equipments such as flow cytometer, Real-Time PCR machine, Hi-speed centrifuges, -80° C freezers etc. have been procured and installed.

Establishment of Biotech Hubs for the North Eastern States

A Biotech Hub Scheme was initiated during the year 2010-11 and continuing during 2011-12 with the broad purpose of promotion of education and research in Biology/Life Science/Biotechnology. Institutes/Colleges/Universities of higher education of the

North Eastern Region of India offering undergraduate and/or postgraduate courses in any branch of Biology/Life Science/Biotechnology/Environmental Science/Chemistry /Physics/ Computer Science /Biomedical Sciences/ Agri/ Veterinary Sciences for 3 years to establish/upgrade a basic biotechnology lab, develop a bioinformatics center, avail biotechnology e-journal, support for organizing training for teachers etc. 6 State level and 34 institutional level biotech hubs were established and 52 additional institutional level biotech hubs sanctioned at various colleges/universities/institutes during this year. These facilities will impart research insight among the budding science students at their formative stage of science education (UG/PG level) and research career (PhD level).

North Eastern Bioinformatics Network (NEBINet)

Twenty seven bioinformatics centers established in all the 8 states of the NER were networked as the North Eastern Bioinformatics Network (NEBINet). These Bioinformatics centres are provided with latest IT equipment to support the research activities of the host institutions in NER. The network is quite popular in outreach of various programmes to NER in addition to information collection and dissemination.

DBT's e-Library Consortia (NER-DeLCON)

DBT's e-Library Consortia for North Eastern Region (NER-DeLCON) was established in the year 2010 through which more than 900 High Impact e-journals were subscribed by DBT and the facility was offered to 15 selected NER institutions. During the year 2011, 3 new institutions were added from NER in the consortia. An assessment indicated that scientists, faculty and students of these 18 institutions were using the subscribed e-journals extensively and also encouraging institutions in the neighborhood to utilize this service. DeLCON may be accessed at www.delcon.gov.in.

BABRONE

During the year, DBT has sanctioned a project on creation of an online human resource repository of Biotechnology and Bioinformatics resources of North East India (BABRONE). This online repository will be first of its kind that will provide comprehensive information regarding biotechnology and bioinformatics resources of NE India preferably via open-source software.

Network Program on Development of Digital Database of Bioresource of NER India

A network programme with 8 PIs from 7 different institutes of NER on development of a digital database of bio-resources of North East India has been sanctioned by DST. The Programme is aimed at digitizing, structuring, developing suitable databases and makes it available in the public domain. The duration of the project is for 3 years with a budget of Rs. 258 lakhs.

Human Resource Development

Overseas Associateship for NER scientists

A special programme was developed to train early and mid-career Scientists holding permanent positions in NE region conducting research to generate human resource in cutting edge areas of biotechnology. The Overseas Fellowship has been awarded for both short (3 & 6 months) and long (1 year) term period. During the last year 21 scientists availed associateship in established institutions in different foreign countries including USA, Japan, Canada, UK, Germany and France. During this year Seven Overseas Fellowship has been awarded to for long term training while 27 were approved for short term period.

Award of Biotechnology National Associateship to Scientists working in North Eastern States

National Associateship Programme for training both for short term and long term has been initiated for the award of Biotechnology National Associateship for conducting research or training in National Institutions/research laboratories in different areas of biotechnology such as (i) agriculture, food and feed biotechnology; (ii) animal biotechnology; (iii) aquaculture and marine biotechnology; (iv) food and nutrition; (v) environmental biotechnology (vi) industrial biotechnology: materials biotechnology, reaction and process design; (vii) medical biotechnology; (viii) nano-biotechnology and bioengineering; (ix) bioinformatics and IT-enabled biotechnology; (x) intellectual property and patent law.

Entrepreneurship Development in NER

DBT had entrusted a project to Biotech Consortium India Limited (BCIL) to organize a series of Entrepreneurship Development Programmes (EDPs) in NER for handholding the budding entrepreneurs and assisting

them in establishment of a successful enterprise in NER.

A training programme on entrepreneurship development sanctioned to The Energy & Resources Institute (TERI), Guwahati for production of superior quality planting material using *in vitro* technology in Northeast India. This programme aimed at enhancing the technical capability of the entrepreneurs and scientists researching/engaged in mass production of tissue cultured plants and appraising them about the current development in this field.

Centres of Excellence

For strengthening agro-biotechnology research in NER, DBT partnered with Assam Agricultural University, Jorhat to establish a 'DBT-AAU centre for Agriculture Biotechnology' at AAU, Jorhat. The major focus of the centre will be on: (a) Basic research-Gene technology, molecular breeding and microbial gene prospecting, (b) HRD component with strong Ph.D. programme, and (c) Extending technology benefits through enhanced production of bio inputs etc.



NEW LEGISLATIONS AND REGULATIONS

DNA Profiling Bill

Human DNA Profiling Bill has been formulated by the Department in consultation with the Centre for DNA Fingerprinting and Diagnostics, Hyderabad. The objectives of this Bill are to regulate the use of DNA analysis of body substance profiles; making provision for establishment of DNA Profiling Board to lay down standards for laboratories, collection of body substances; to establish a National and /or State DNA Data Banks to create policies for use and access to information from data bank etc. and for matters connected therewith or incidental thereto. The Draft Bill was subsequently circulated to the concerned Ministries and Departments of the Central Government to obtain their comments. The draft Bill has since been revised, wherever necessary, according to the comments received. Draft Bill has been sent to the Chief Secretaries of all the States for information and feedback. The document is being further revised based on the discussion held with the experts to bring more clarity on various issues.

Regional Centre for Biotechnology (RCB) Bill

Regional Centre for Biotechnology would be an international nodal institution for biotechnological sciences at the interface of multiple disciplines and would be an autonomous body under the statute of Parliament as an institution of international importance for biotechnological Education, Training and Research. Hon'ble Minister for Science & Technology and Earth Sciences introduced a Bill (Item No. 27) during the winter session (9th Session of XV Lok Sabha) on 20th December, 2011 to facilitate the establishment of the institution and Training and Education as Category-II institution under the auspices of UNESCO to undertake research in the field of biotechnology and to provide for matters connected therewith or incidentally thereto.

Biotechnology Regulatory Authority of India (BRAI) Bill, 2010

BRAI will be an independent, autonomous, statutory agency and will be established

through the act of parliament by the Government of India to safeguard the health and safety of the people of India and to protect the environment by identifying risks posed by, or as a result of, modern biotechnology and managing those risks through regulating the safe development and deployment of biotechnology products and processes. The Authority will be

responsible for regulating the research, transport, import, manufacture and use of organisms and products in health care, agriculture, veterinary and environment. The BRAI bill after cabinet approval has been tabled in Lok Sabha for introduction. A detailed establishment plan has been prepared with requirements of human resource, infrastructure and managerial aspects.



ADMINISTRATION AND FINANCE

Administration

Administration is responsible to provide a good and ambient working atmosphere for the in-house scientists, officers and staff. Logistic supports were given for organising various Task Force & Expert Committee meetings successfully. Modern office equipments like laptops, computers, multimedia projectors, photocopiers, etc. were made available within the Department to maximise the work output. Being a scientific department, a large number of meetings, interactions and quick referral with technical experts, specialists, academicians and scholars from far reaching places and across the world are held. Therefore, to obviate unnecessary travelling and to minimise expenditure on this account, an effective Video Conferencing System has been made operational in the Department. The System is widely used in the Department for such purpose.

Presently, the Department does not have its own building or campus and is facing shortage of office space. This has restricted the long felt expansion plan of the Department. Two pronged strategies are

being taken to tackle the issue- first by getting some additional built-up office space and second by getting a piece of land to make its own building.

Establishment

Establishment Division has been entrusted with the functions relating to mainly the service matters of in-house scientists, officers and staff of the Department. These matters include their recruitment & promotion to various posts, Flexible Complementing Scheme (FCS), grant of financial up-gradation under ACP/MACP Scheme, reimbursement of medical claims, grant of various advances etc. During the period under report 1 post of Scientist 'C', 2 posts of Junior Analyst and 5 posts of Multi Tasking Staff were filled up on direct recruitment basis. Under Flexible Complementing Scheme (FCS), One Scientist of the department was promoted i.e. one from Scientist 'E' to Scientist 'F' and seven cases of grant of promotion to their next higher grade under FCS were also processed. 12 officials were granted financial up-gradation under the Modified Assured

Career Progression (MACP) scheme. The officers and staff were deputed for various training programme conducted by the institute of Secretariat Training & Management, National Productivity Council and other such institutes to enhance their skills in relevant fields.

The category-wise position of posts sanctioned and filled as on 31.12.2011 is as under:-

Category of posts	Posts sanctioned	Posts filled
Group 'A'	76+8 Plan	66+2 Plan
Group 'B'	89	66
Group 'C'	87+1 Plan	67+1 Plan
Total	252+ 9 Plan	199

Parliamentary matters

No meeting had been held during April – December, 2011.

Grievance Redressal

Department has established an effective grievance redressal mechanism to deal with the public as well as the staff grievance petitions. All public grievances received during the period of April-December, 2011,

Representation of SC/ST/OBC/PH: The number of SC/ST/OBC/PH employees in various posts as on 31.12.2011 is as under:

Groups/	Group 'A'	Group 'B'	Group 'C'	Grand Total
Sectioned strength/ Total Filled	76+8 Plan	89	87+1 Plan	252+9 Plan
	66+2 Plan	66	67+1 Plan	199+3 Plan
Scheduled Castes	02	10	21	33
Scheduled Tribes	03	03	09	15
Other Backward Classes	-	06	04	10
Physically Handicapped	02	03	-	05

were disposed of in a time bound manner. The department regularly updated progress, disposal and pendency of public grievances on the website of Department of Reforms & Public Grievances.

Vigilance Unit

A Vigilance Cell is functioning in the Department to handle vigilance and complaint cases expeditiously. During the period of April – December, 2011, only 3 vigilance case was registered. However, complaints received from various sources were processed timely and the Central Vigilance Commission was kept apprised of the progress and final outcome of these complaints. In pursuance of the instructions of the Central Vigilance Commission, a 'Vigilance Awareness Week' was observed in the Department from 3rd to 7th November, 2011.

Progressive Use of Hindi in the Department

Hindi division ensures progressive use of Hindi and implementation of Government policy on Official Language in the Department. An Official Language Implementation Committee, constituted under the chairmanship of the Joint Secretary (Admn.) in the Department, reviews progressive use of Hindi in every

quarter and suggests corrective measures for promoting use of Hindi. During the year, all documents were issued in bilingual form and the letters received in Hindi were replied to in Hindi only under Section 3(3) of the Official Languages Act, 1963. In order to strengthen the monitoring system of progressive use of Hindi, the officers who sign the papers have been made the check-points. Under Rule 8(4) of the Official Language Rules, 1976, Establishment, Administration, PPVC, Cash sections and Library in the Department have been notified to do their 100% work in Hindi. Hindi fortnight was organized in the Department during 1 - 15th September, 2011, in which 8 different competitive events namely Essay, Hindi-English Translation, Debate, Scientific Articles, Noting & Drafting, Hindi Quiz, Hindi Typing and Antakshari were held to promote use of Hindi in official work. Ten officers and twenty eight other employees were given cash prizes in a prize distribution ceremony organized under the chairmanship of Secretary (DBT) on 19 October, 2011 in which the first prize of Rs.2000/-, second prize of Rs.1500/-, third prize of Rs.1200/- and 5 consolation prizes of Rs.1000/- were given. Secretary, DBT gave away the prizes and through his speech motivated the officers and staff to work in hindi. With a view to encourage writing original books on biotechnology related subjects in Hindi, the

Department has been carrying out an award scheme namely “Dr. Jagdish Chandra Bose Hindi Granth Lekhan Puraskar Yojna” since 2002. Under this scheme, one second prize for Rs. 50,000/-, one third prize for Rs. 25,000/- and two consolation prizes for Rs. 10,000/- each were awarded for the selected books for the year 2009. During the year, 103 officers/employees were imparted training in three Hindi workshops/Scientific Symposia organized in the Department during the year. All the Sections/Divisions of the Department were inspected by the officials of Hindi section during the year in order to ensure the progressive use of Hindi as well as to facilitate officials of the various Divisions for making them more efficient in Hindi working. In order to review the implementation of official language hindi in the department’s autonomous bodies/ public sector undertakings, an inspection has already been carried out in the Regional Centre of Biotechnology, Thiruvananthapuram (Kerala) and inspection of other four offices such as NII, New Delhi; NIPGR, New Delhi; NBRC, Gurgaon and BIBCOLD, Bulandshahar are scheduled to be carried out by the end of the year of report.

Sports and Cultural Activities

A number of DBT officials participated in the Inter-ministry Tournaments 2011-12 and

distinguished themselves with excellent performance. Dr. Gulshan Wadhwa, Ms. Alka Mankad, Ms. Rajani Kushwaha and Ms. Mahak Garg represented DBT in Inter-Ministry Badminton Tournament 2011-12 held at AIIMS, Gymkhana, New Delhi and Ms. Alka Mankad won Silver Medal in Women Doubles (Veteran). Ms. Rajani Kushwaha, Mr. Anurag Mishra, Ms. Mahak Garg and Mr. D. Rajshekhar represented DBT in Inter-Ministry Chess Tournament 2011-12 held at Nirman Bhawan, New Delhi, for the first time. The officials of Department of Biotechnology are also participated in the Inter-Ministry Music & Dance and Short Play Competition, 2011-12 in the events of Folk Dance – Solo and Folk Dance-group, Western Dance and Folk Music categories.



Fig.15.1

99th Indian Science Congress

Dr. Manmohan Singh, Hon'ble Prime Minister inaugurated the 99th Indian Science Congress held at KIIT, Bhubaneswar on

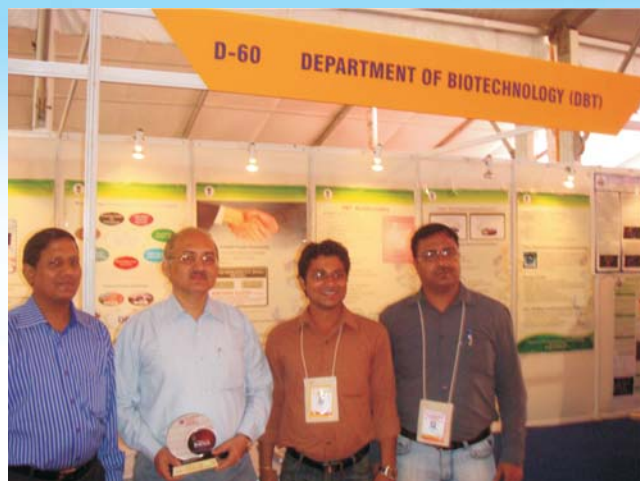


Fig.15.2

3rd – 7th January, 2012. The Focal theme for the Science Congress was “Science and Technology for Inclusive Growth of women”. The Exhibition on “Pride of India” was inaugurated by Shri Vilas Rao Deshmukh, Hon’ble Minister for Science and Technology and Earth Sciences.

More than 12000 registered delegates from India and abroad, including five Nobel Laureates have participated in the Science Congress. The Department took part in the exhibition during the science congress with illustration of DBT’s major activities,

programmes and new schemes. Noble Laureates visited the DBT exhibition stall, enthusiastically interacted on various programmes of DBT. Dr. Gulshan Wadhwa, Dr. Peyush Goyal, Shri Anadi Sharma, Ranjit Singh, Shri Pramod Kumar and Shri Narendra Kumar from the Department coordinated the exhibition as two teams. Statistics in Bioinformatics – an exclusive session was held in the Science Congress, which was chaired by Dr. T. Madhan Mohan, Adviser, DBT.

Finance

The Department of Biotechnology was allocated an amount of Rs.1426.92 Crores (Rs. 1400.00 Crores (Plan) and Rs.26.92 Crores (Non-Plan) for the year 2011-12. This was revised to Rs.1376.70 Crores (Rs. 1350.00 Crores (Plan) and Rs.26.70 Crores (Non-Plan)). The financial statement showing the details of actual expenditure during 2010-11, B.E. and R.E. 2011-12 in respect of various programmes/schemes is enclosed in Annexure-V.



ANNEXURES

The short term training programmes conducted during the year

S. No.	Title of the Programmes	Organizers	Duration	No. of Participants
1.	Molecular Biology Techniques in Microbiology	Dr. Prakash M. Halami, Scientist E1, Food Microbiology Department, Central Food Technology Research Institute (CFTRI), Mysore, Karnataka-570020	4 th -19 th March, 2011	15
2.	Agroindustrial applications of plant tissue culture, <i>Agrobacterium</i> mediated gene transfer and PCR techniques	Dr. S. Rathinavel Associate Professor PG and Research Department of Botany, Saraswathi Narayanan College (Autonomous) Madurai-625022 (T.N)	23 rd May to 11 th June, 2011	15
3.	Cynobacterial Sequencing Techniques	Dr. L. Uma, Director, National Facility for Marine Cynobacteria, Department of Marine Biotechnology, Bharathidasan University, Tiruchirappalli-620024 (T.N)	27 th Feb to 9 th March, 2012	15
4.	Methods in Biotechnology, molecular biology and bioinformatics	Dr. J. Joel Gnanadoss, Assistant Professor, Department of Plant Biology and Biotechnology Loyola College (Autonomous) Chennai-600034 (T.N)	1 st - 21 st Feb, 2012	15

Annexure-II

**Number of Biotechnology students trained by companies under
Biotech Industrial Training Program (BITP) during 2011**

S. No.	Name of com[pany	No. of students trained
1	Abexome Biosciences Pvt Ltd	5
2	Advanta India Limited	1
3	Advinus Therapeutics Limited	1
4	AG Biotech Laboratories (I) Ltd.	3
5	Agri Biotech Foundation	3
6	Aptus Biosciences Pvt Ltd	3
7	Ara Healthcare Pvt Ltd	15
8	Arbro Pharmaceuticals Ltd	2
9	Aristogene Biosciences Pvt Ltd	4
10	Ashmar Technologies and Research Pvt Ltd	2
11	Asian Institute of Gastroenterology	4
12	AstraZeneca Pharma India Ltd	3
13	Atash Seeds Pvt. Ltd	1
14	Aumgene Biosciences Pvt. Ltd.	3
15	Aurigene Discovery Technologies Limited.	1
16	Aurobindo Pharma Ltd	2
17	Auromed Laboratories	100
18	Avesthagen Limited	3
19	Azyme Biosciences Pvt Ltd.	1
20	Bangalore Biotech Labs Pvt. Ltd.	45
21	Barwale Foundation	8
22	Beckman Coulter India Pvt Ltd	1
23	Bejo Sheetal Seeds Pvt Ltd	4
24	Best Biotech Research labs (P) Ltd.	2
25	Bharat Immunologicals and Biologicals Corporation Ltd	2
26	Bharat Serums and Vaccines Ltd	2

S. No.	Name of com[pany	No. of students trained
27	Bhat Bio Tech India P Ltd	6
28	Biocon Ltd.	10
29	Biological E Ltd	10
30	BioMed Informatics	10
31	Bioserve Biotechnologies (India) Pvt Ltd.	7
32	Bio-tech Laboratory, Neri, Unit of Ankur Seeds Pvt. Ltd.	6
33	Cavinkare Pvt Ltd	1
34	Century Pharmaceuticals Ltd	2
35	Clairvortex Knowledge Processes Pvt. Ltd.	1
36	Clonz Biotech Private Ltd	1
37	Codon Biotech Private Limited	6
38	CPB India P Ltd	1
39	Dabur Research Foundation	9
40	Dr.Surapaneni's Genomic Solutions Pvt Ltd	4
41	Embio Limited	2
42	Enzene Biosciences Private Limited	4
43	Epitome Consulting and Information Technology Pvt. Ltd.	1
44	Gangagen Biotechnologies P Ltd	1
45	Gennova Biopharmaceuticals Limited	8
46	Geno Biosciences Pvt Ltd	1
47	Genotypic Technology Pvt Ltd	3
48	GenPro Biotech	4
49	Global Transgenes Ltd	1
50	GVK BioSciences Pvt Ltd	2
51	Hash BioTech Labs Pvt Ltd	7
52	Health Line Pvt Ltd	1
53	Healthcare Global Enterprises Ltd	1
54	Imgenex India Pvt Ltd	9
55	Indian Immunologicals Ltd	6
56	Indo-American Hybrid Seeds (India) Pvt. Ltd.	11

S. No.	Name of com[pany	No. of students trained
57	Indus Seeds	6
58	Institute of Molecular Medicine	1
59	Intas Biopharmaceuticals	10
60	Jai Biotech Industries	1
61	Jai Research Foundation	1
62	Jay Biotech	4
63	JK Agri Genetics Ltd	6
64	Juan Biotechnology Private Limited	3
65	Jubilant Biosys Limited	11
66	Kaveri Seed Company Ltd	2
67	KEE GAD Biogen Pvt. Ltd.	3
68	Kemwell Pvt Ltd	1
69	Kilpest India Limited	1
70	Krishidhan Research Foundation Limited	1
71	L J International Ltd	1
72	Labland Biotech Pvt Ltd	7
73	Laila Pharmaceuticals Pvt Ltd	3
74	Leadinvent Tech Pvt Ltd	1
75	Lifecare Innovations Pvt Ltd	2
76	Lonza India Pvt Ltd	2
77	Maharashtra Hybrid Seeds Co. Ltd.	1
78	Maharashtra State Seeds Corporation Limited	5
79	Manipal Acunova Ltd.	2
80	Mediclone Biotech Pvt. Ltd	10
81	Metaome Science Informatics (P) Ltd	5
82	Micro Labs Ltd	1
83	MITCON Consultancy Services Ltd.	4
84	Monsanto Holding Private Limited	1
85	Myko Tech Private Limited	1
86	Nandan Biomatrix Limited	2

S. No.	Name of com[pany	No. of students trained
87	Natural Remedies Pvt Ltd	8
88	Nectar lifesciences ltd	2
89	Nirmal Seeds India Pvt Ltd	4
90	Ocimum Biosolutions	3
91	OncQuest Laboratories Ltd	6
92	Orchid Chemicals & Pharmaceuticals Ltd	8
93	Oriental Aquamarine Biotech India Private Limited	3
94	Panacea Biotec Ltd	5
95	Pelican Biotech and Chemical Labs Pvt Ltd	3
96	Perfint Healthcare Pvt Ltd	3
97	Piramal Diagnostic Services P Ltd	1
98	Polyclone Bioservices Pvt Ltd	1
99	Praj Industries Limited	4
100	Pranav Agro Industries ltd	1
101	Premas Biotech Pvt. Ltd	2
102	Probiosys	3
103	Prosetta Bioconformatics Pvt Ltd	1
104	Radiant Research Services Pvt. Ltd.	3
105	Rashmi Pharma Pvt. Ltd.	1
106	Rishi Herbal Technologies Pvt Ltd	4
107	Roche Diagnostics India Pvt Ltd	2
108	S&S Agro Biotech Pvt Ltd	4
109	S.P.Y Agro Industries Ltd.	2
110	S4BIO	7
111	Sai Lara Biotechnologies	4
112	Sandor Proteomics Pvt Ltd	6
113	Sangenomics Research Labs Pvt Ltd	2
114	Serum Institute of India	1
115	Shantha Biotechnics ltd	4
116	Shodhaka Life Sciences Pvt. Ltd	5

S. No.	Name of com[pany	No. of students trained
117	Shri Meera Labs Pvt Ltd	5
118	Simbiosys Biowares India Pvt Ltd	1
119	Span Diagnostics Limited	3
120	SPC Biotech Private Limited	4
121	Sri Biotech Laboratories India Limited	3
122	Sri Raghavendra Biotechnologies P Ltd	9
123	Subhash Fertilizer Private Limited	2
124	Subhasree Biotech	4
125	Sugen Life Sciences Pvt Ltd	8
126	Sun Agrigenetics P. Ltd.	5
127	Super Religare Laboratories Ltd	2
128	Surya Pharmaceutical	1
129	T Stanes and Company Ltd	9
130	Tapadia Diagnostic Centre	1
131	Tata International Ltd	1
132	Tectona Biotech Resource Centre	9
133	Tex Biosciences P Ltd	1
134	The Gene Tech	2
135	Tropilite Foods Pvt Ltd	2
136	Tulasi Seeds Pvt. Ltd.	1
137	UB Nizam Breweries Pvt. Ltd.	1
138	United Breweries Limited	2
139	Vasantdada Sugar Institute (VSI)	1
140	Vimta Labs Ltd	3
141	Virchow Biotech Pvt. Ltd.	1
142	Vittal Mallya Scientific Research foundation	1
143	Vivo Biotech Ltd	2
144	Wockhardt Limited	4
145	Xpression Biotek Pvt Ltd	3
146	Zenotech Laboratories Ltd	2

Annexure-III

Products /Processes under development through BIPP support

S. No.	Company/Collaborator(s) Name	Product/Process description
	Health Care/Drugs/Vaccines	
1.	Torrent Pharmaceuticals Limited, Gandhinagar	Drug for Diabetes associated Heart Failure
2.	ARA Healthcare Limited, Gurgaon	Anti- TNF-alpha Antibody scFv for treatment of Inflammatory Diseases
	TCG Life Sciences Limited, Kolkata	Process for Asymmetric Synthesis of Hexahydrobenzophenanthrenes, Dopamine D1 Agonists
	Bharat Serums and Vaccines Limited, Mumbai	Technology development for implant based sustained release formulations incorporating therapeutic peptides/ recombinant proteins
5.	(i) Amrita Therapeutics Limited, Ahmedabad (ii) National Institute of Immunology, New Delhi (iii) B.V. Patel PERD Centre, Ahmedabad	Identification and Development of Promiscuous Anticancer Compounds from Microorganisms
6.	Wockhardt Limited, Aurangabad	Development of animal component free biosimilar recombinant protein therapeutics using mammalian platform technology
7.	Life Care Innovations Pvt. Ltd., Gurgaon	Production of poly (lactide-co-glycolide) nanoparticles (PLG-NP)and poly (lactide-co-glycolide) nanoparticles encapsulating antitubercular drugs (rifampicin, isoniazid and pyrazinamide- PLG-NP-ATDs) in GMP facilities

S. No.	Company/Collaborator(s) Name	Product/Process description
8.	Virchow Biotech Private Ltd., Hyderabad	Mucosal Vaccine For HPV
9.	Gennova Biopharmaceuticals Limited, Pune	Recombinant Human Papillomavirus vaccine
10.	Gennova Biopharmaceuticals Limited, Pune	Bio-similar interferon beta 1a: process development
11.	(i) Serum Institute of India Limited, Pune (ii) Indian Institute of Science, Bangalore (iii) National Institute of Immunology, New Delhi	Immunogens and monoclonal antibodies against pandemic H1N1
12.	Serum Institute of India Limited, Pune	Clinical Development of Polysialylated Erythropoietin
13.	Serum Institute of India Ltd., Pune	Development of HPV Vaccine
14.	(i) RAS Life Sciences, Hyderabad (ii) Institute of Liver and Billiary Sciences, New Delhi	Development of HCV genotype 3a based replicon system
15.	(i) Sphaera, Manesar (ii) Leadinvent, Delhi (iii) International Centre for Genetic Engineering and Biotechnology , New Delhi	Novel combination therapy for treatment of resistant and non responsive cancers
16.	Tergene Biotech Pvt. Ltd., Secunderabad	Development of an Affordable, Asia specific 15 valent Pneumococcal Ploysaccharide - CRM 197 protein conjugate Vaccine

S. No.	Company/Collaborator(s) Name	Product/Process description
17.	Rasayani Biologics Pvt. Ltd.	Evaluation of Platinum Nano Particles for the Treatment of Hormone Refractory Prostate Cancer
Health Care/Diagnostics		
18.	Bigtec Private Limited, Bangalore	Point-of-Care detection of infectious disease using handheld microPCR
19.	Amar Immunodiagnostics Pvt. Ltd., Hyderabad	Immunodiagnostic kits for detection of autoimmune diseases
20.	Abexome, Bangalore	Establishment of vitro phamacological Assay platform for biosimilars
21.	Revelations Biotech Pvt. Ltd., Hyderabad	Development of low cost rapid quantitative PCR technology for molecular diagnosis
22.	Chromous Biotech Pvt. Ltd., Bangalore	Multiplex Fast-PCR based diagnosis and prognosis of tuberclulosis
Health Care/Clinical Trial		
23.	(iv) Bharat Biotech International Limited, Hyderabad (v) Christian Medical College, Vellore (vi) KEM Hospital Research Centre, Pune (vii) Translational Health Science and Technology Institute, New Delhi	Rotavirus Vaccine Candidate 116E
24.	Torrent Pharmaceuticals Limited, Gandhinagar	Clinical development of TRC150094, a novel Diiodothyronine (T2) analogue, for the treatment of cardiovascular (CV) risk factors defined by Metabolic Syndrome (MS).

S. No.	Company/Collaborator(s) Name	Product/Process description
25.	Biocon Limited, Bangalore	A Multicenter, Randomized, Double-Blind, Placebo Control Study of IN-105 tablets [oral insulin] in Patients with Type 2 Diabetes Mellitus who have inadequate Glycemic Control on Optimal doses of Extended Release Metformin Tablets.
26.	Biocon Limited, Bangalore	Open label, randomized, Multicentric studies to Compare safety and efficacy of Recombinant insulin aspart-biphasic and regular with NovoLog® Mix 70/30 and NovoRapid in T1DM and T2DM patients
27.	Panacea Biotech Limited, New Delhi	H1N1 pandemic influenza vaccine
28.	V-Life Sciences Technology Pvt. Ltd., Pune	Clinical Investigation of Galnobax for the treatment of Diabetic foot Ulcers
29.	Biological E Limited., Hyderabad	A Multicentric, Parallel Randomised (2:1) Open Label Phase III Clinical Study To Evaluate The Immunogenicity And Safety Of BE's Inactivated JE Vaccine In Healthy e"1 To <3 Year Old Indian Subjects In Comparison With Purified Inactivated JE Vaccine (IXIARO®) Of Intercell – An Non-Inferiority Study
30.	Stempeutics Research Pvt. Ltd., Bangalore	A Randomized, Double Blind, multicentric, placebo controlled, Phase-II study assessing the safety and efficacy of Intraarterial (Hepatic) Ex-vivo cultured adult allogenic mesenchymal stem cells in patients with liver cirrhosis
31.	Crystalin Research Pvt. LTD.	Clinical trials of novel anticancer drug cocrystal

S. No.	Company/Collaborator(s) Name	Product/Process description
Health Care		
32.	Perfint Healthcare Pvt. Ltd., Chennai	Solution for planning, execution and confirmation of targeted ablation therapy
33.	Strand Life Science, Bangalore	Hepatotoxicity prediction platform
34.	Frontier Lifeline Private Limited, Chennai	Porcine Pulmonary Xenograft as a Conduit in Cardiovascular Surgery
35.	IMGENEX India Pvt. Ltd., Bhubaneswar	Development of High Expression plasmid vectors for production of biosimilar herceptin and other recombinant proteins and antibodies
36.	Intas Biopharmaceuticals Pvt. Ltd., Ahmedabad	Mucosal formulations of Parathyroid hormone (PTH)
37.	Incozen Therapeutics Pvt. Ltd., Hyderabad	Discovery and Development of potent, selective and novel c-Met kinase inhibitors in cancer
38.	Vinvish Technologies Pvt. Ltd., Trivendrum	Design and Development of photo dynamic therapy laser system
39.	Transasia Biomedical Ltd., Mumbai	To develop novel 3rd Generation HIV (Antibody) & 4th generation (HIV Antigen and Antibody) immunoassay forma using flash type chemiluminescence and magnetic particles as matrix
40.	Agada Medical Technologies	Percutaneous Aortic Valve Technology
Agriculture		
1.	Maharashtra Hybrid Seeds Company Limited, Jalna	Stress tolerant rice
2.	Maharashtra Hybrid Seeds Company Limited	Sucking Insect Pest tolerant rice and cotton

S. No.	Company/Collaborator(s) Name	Product/Process description
3.	Metahelix Life Sciences Private Limited, Bangalore	Transgenic rice tolerant to rice yellow stem borer
4.	Metahelix Life Sciences Private Limited, Bangalore	Deregulation Trials Phase I of Transgenic Maize Events Expressing Metahelix Synthetic Cry1C, Cry1Ac and Cry1Ab Genes for Tolerance to Stem and Cob Borers
5.	Kaveri Seeds Company Ltd., Secunderabad	Development of biotic stress resistant rice through conjunct use of bio-and hybrid technologies
6.	JK Agri Genetics Ltd., Hyderabad	Development of Bt-rice with two cry genes
7.	Advanta India Limited, Secunderabad	Drought and multiple diseases & pests tolerant rice through Multi stacking genes
8.	(i) Advanta India Limited, Secunderabad (ii) Indian Agriculture Research Institute, New Delhi	RNAi and other cutting edge technological interventions to develop insect-pest diseases & viruses tolerant tomato hybrids for Indian & International markets
9.	(i) Bejo Sheetal Seeds Private Limited, Jalna(ii) International Centre for Genetic Engineering and Biotechnology , New Delhi	'Herbicide & Stress tolerant' transgenic Onion
10.	(i) Sri Biotech Laboratories India Ltd., Hyderabad (ii) University of Delhi South Campus, Delhi	Control of Shoot and Fruit Borer Insect Pest (Leucinodes orbonalis Guenée) in Brinjal Through RNA interference
11.	Mother Dairy Fruit and Vegetable Private Limited, Noida	To conduct confined field trials and biosafety studies on genetically engineered Brassica juncea (Male sterility and restorer lines as pollination control mechanism) for heterosis breeding and yield improvement

S. No.	Company/Collaborator(s) Name	Product/Process description
12.	Tata Chemicals Limited, Pune	Inorganic and polymer nano-composites for micronutrient & pesticide delivery: Boosting crop health and yield.
13.	(i) Nirmal Seeds Pvt. Ltd., Jalgaon(ii) The Energy and Resources Institute, New Delhi	Development of nutritionally improved mustard (Brassica juncea) varieties/hybrids having low erucic acid and low glucosinolate content using marker assisted selection
14.	Ankur Seeds Pvt. Ltd., Nagpur	Third generation RNAi for engineering Tomato leaf curl (ToLCV) and tospovirus (GBNV) resistance in tomato
15.	Stellence PharmScience Ltd., Bangalore	Development of a bio-efficacious value-added novel neem-based biopesticide formulation
16.	Bioseed Research India Ltd., Hyderabad	Development of rice hybrids with improved drought and salinity stress tolerance
17.	Sri Biotech Laboratories India Ltd., Hyderabad	Development of Actinomycetes based metabolites as delivery systems for soil health management in Groundnut
18.	Abhay Cotex India Pvt.	Single step extraction of cottonseed with miscella refining
Energy		
1.	Avesthagen Limited, Bangalore	Self-glucogenic Pearl Millet for Bio-ethanol products
2.	Richcore Lifesciences Pvt Ltd., Bangalore	A process for Enhanced Ethanol Yield from Molasses Fermentation
3.	Nagarjuna Fertilizers and Chemical Limited, Hyderabad	Biological Hydrogen Production

S. No.	Company/Collaborator(s) Name	Product/Process description
4.	(i) Bharat Petroleum Corporation Limited, Greater Noida (ii) The Energy and Resources institute, New Delhi	Butanol production from lignocellulosic biomass
5.	Thermax Limited, Pune	Anaerobic Membrane Bioreactor (AnMBR) for Waste to Energy Solutions
6.	India Glycols Limited, Kashipur	Setting up a 10 ton Lignocellulosic biomass/day processing plant to produce about 3000 Litre ethanol/day
7.	SPC Biotech, Hyderabad	Bioconversion of Agricultural Waste from Mango kernel, to Polylactic acid a bio-plastic
Capacity Building through Infrastructure Support		
1.	Span Diagnostics Limited, Surat	Establishment of cGMP compliant Bioprocess Facility for large-scale production of Microbial antigens and Monoclonal antibodies
2.	Intas Biopharmaceuticals Private Limited, Ahmedabad	Facility for high end structural and functional characterization of protein therapeutics and peptides

*Annexure-IV***Gender Budgeting**

As a follow-up of recommendations of the Inter-Departmental Committee set up under the chairmanship of Secretary (Expenditure) to consider issues regarding Gender Budgeting, the Department has established a "Gender Budgeting Cell". The terms of Reference of the Cell are as follows:

- To make an assessment of the benefits reaching women through the existing programmes and schemes of the Department. The assessment is to be reflected in the Annual Report of the Department.
- To come up with specific schemes targeted towards women.
- To clearly bring out scheme-wise provisions and physical targets for benefitting women in the Annual Plan and Performance Budget of the Department.

The Gender Budgeting Cell has taken necessary action as per the guidelines/circular of Ministry of Finance for identifying specific schemes for which budget needs to be earmarked for the benefit of women. Department's social Development Programme on Biotechnology for Women targets the women beneficiaries in terms of both employment and income generation. There is also a Special Biotechnology Award Scheme for encouraging outstanding Women Scientists, In addition, under other schemes quantification regarding number of women beneficiaries has been done in respect of M.Sc./M.Tech. Biotechnology teaching programme, Biotech Industrial Training Programme, fellowships for doctoral and post doctoral research, awards, overseas associateship schemes and other awards including travel support, Star Colleges, Project Investigators (PIs) in DBT funded projects. The details of the gender budgeting is as given below:

Scheme-wise Provisions and Physical Targets Benefiting Women

S. No	Schemes	Total Budget Allocation for the Year 2011-12 (Rs. in crore)	Expenditure incurred to support women during 2011-12 (Rs. in crore)	No. of Women benefitted through various activities during 2011-12	Budget Estimates for financial year 2012-13 to support women	Benefits earmarked for women during 2011-12
1.	Human Resource Development	54	27	1000	No separate budget is earmarked to support women. However, the budget for women programmes is being spent from the total budget allocated for the year 2011-12	The programmes have been supported for R&D, infrastructure strengthening, capacity building, bioinformatics, etc. In addition, special award schemes have been initiated to encourage women scientists and students.
2.	Bioinformatics	19	9.14	32		
3.	Biotech facilities Centres of Excellence and Programme support	27	15.22	98		
4.	R&D	394.40	55.60	405		
5.	Biotechnology for Societal Development	13.00	4.47	7011		
6.	International Cooperation	25	9.80	22		

Financial Statement for Annual Report: 2010-2011

Annexure-V
(Rs. in Crore)

S. NO.	Name of the Programmes/Schemes	Actual Expenditure 2010-11			BE 2011-12			RE 2011-12		
		Plan	Non-Plan	TOTAL	Plan	Non-Plan	TOTAL	Plan	Non-Plan	TOTAL
1	2	3	4	5	6	7	8	12	13	14
	REVENUE SECTION	1120.55	24.31	1144.86	1400.00	26.92	1426.92	1350.00	26.70	1376.70
1	Secretariat Economic Services									
1.01	Secretariat	0	12.31	12.31	0	14.67	14.67	0	14.45	14.45
2	Autonomous R & D Institution	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00
2.01	National Institute of Immunology	53.00	1.60	54.60	58.00	1.80	59.80	58.00	1.80	59.80
2.02	National Centre for Cell Science	44.00	0.40	44.40	37.00	0.45	37.45	33.00	0.45	33.45
2.03	Centre for DNA Finger Printing and Diagnostics	24.00	0.00	24.00	29.00	0.00	29.00	35.00	0.00	35.00
2.04	National Brain Research Centre	24.00	0.00	24.00	29.00	0.00	29.00	29.00	0.00	29.00
2.05	National Centre for Plant Genome Research	23.25	0.00	23.25	29.00	0.00	29.00	22.00	0.00	22.00
2.06	Institute of Bioresources & Sustainable Development	6.88	0.00	6.88	0.10	0.00	0.10	0.10	0.00	0.10
2.07	Institute of Life Sciences	25.00	0.00	25.00	24.00	0.00	24.00	35.00	0.00	35.00
2.08	Translational Health Science & Technology Institute	20.00	0.00	20.00	13.00	0.00	13.00	13.00	0.00	13.00
2.09	Rajiv Gandhi Centre for Biotechnology	32.00	0.00	32.00	28.00	0.00	28.00	22.00	0.00	22.00

S. NO.	Name of the Programmes/Schemes	Actual Expenditure 2010-11			BE 2011-12			RE 2011-12		
		Plan	Non-Plan	TOTAL	Plan	Non-Plan	TOTAL	Plan	Non-Plan	TOTAL
1	2	3	4	5	6	7	8	12	13	14
2.1	UNESCO Regional Centre for Education and Training, Faridabad	29.26	0.00	29.26	34.00	0.00	34.00	34.00	0.00	34.00
2.11	National Agri-Food Biotechnology Institute & Bioprocessing Unit, Mohali	20.00	0.00	20.00	34.00	0.00	34.00	25.00	0.00	25.00
2.12	Institute for Stem Cell Research & Regenerative Medicine, Bengaluru	12.38	0.00	12.38	24.00	0.00	24.00	25.16	0.00	25.16
2.13	National Institute of Biomedical Genomics, Kalyani	16.00	0.00	16.00	23.00	0.00	23.00	23.00	0.00	23.00
2.14	National Institute of Animal Biotechnology, Hyderabad	0.50	0.00	0.50	14.00	0.00	14.00	14.00	0.00	14.00
	Total = Autonomous R&D Institutions	330.27	2.00	332.27	376.10	2.25	378.35	368.26	2.25	370.51
3	Assistance to other Scientific Bodies		0.00	0.00			0.00			0.00
3.01	Human Resource Development	54.58	0.00	54.58	63.00	0.00	63.00	70.00	0.00	70.00
3.02	Bioinformatics	26.70	0.00	26.70	27.00	0.00	27.00	27.00	0.00	27.00
3.03	Research & Development	437.37	0.00	437.37	418.90	0.00	418.90	420.00	0.00	420.00
3.04	Biotechnology for Societal Development	8.68	0.00	8.68	15.00	0.00	15.00	13.00	0.00	13.00

S. NO.	Name of the Programmes/Schemes	Actual Expenditure 2010-11				BE 2011-12			RE 2011-12		
		Plan	Non-Plan	TOTAL		Plan	Non-Plan	TOTAL	Plan	Non-Plan	TOTAL
1	2	3	4	5		6	7	8	12	13	14
3.05	Grand Challenge Programmes	64.74	0.00	64.74		59.00	0.00	59.00	54.00	0.00	54.00
3.06	Programme For Promotion of Excellence & Innovation	51.00	0.00	51.00		54.00	0.00	54.00	55.00	0.00	55.00
3.07	Biotech Facilities	30.00	0.00	30.00		36.00	0.00	36.00	46.00	0.00	46.00
4.01	I & M Sector - Assistance for Tech. Incubators, Pilot project, Biotechnology Parks	92.52	0.00	92.52		20.00	0.00	20.00	12.00	0.00	12.00
4.02	I&M Sector - Public Private Partnership		0.00	0.00		158.00	0.00	158.00	118.74	0.00	118.74
5	International Cooperation	24.69	0.00	24.69		33.00	0.00	33.00	31.00	0.00	31.00
6	I.C.G.E.B	0.00	10.00	10.00		0.00	10.00	10.00	0.00	10.00	10.00
7	Provisions for projects/ schemes for the benefit of North Eastern Region and Sikkim	0.00	0.00	0.00		140.00	0.00	140.00	135.00	0.00	135.00
	TOTAL = Revenue Section	1120.55	24.31	1144.86		1400.00	26.92	1426.92	1350.00	26.70	1376.70

Annexure – VI

List of patents filed/ granted during 2011-2012

National Institute of Immunology, New Delhi

1. Recombinant sp_0845 protein as an anti-pneumococcal vaccine. Patent application No. 1047/DEL/2011 dated 11.04.2011.
2. Isolation, cloning, sequencing and functional analysis of beta-casein promoter along with the regions of exon1, intron1 and exon2 using mammary gland derived cell line of buffalo (*Bubalus bubalis*). Patent application No. 1112/DEL/2011 dated 15/4/2011.
3. Rhodanine compounds as tubulin binding anti- cancer agent and their application in treating cancers. Patent application No. 1167/DEL/2011 dated 20.04.2011.
4. Synthetic peptides and random copolymers for the treatment of autoimmune disorders. Patent application No. 1313/DEL/2011 dated 05.05.2011.
5. Knock down model of dickkopf homologue 3 (dkk3) for assessing role

of said dkk3 in spermatogenesis and sex reversal. Patent application No. U.S. 13/102,682 dated 06.05.2011.

6. A Novel typhoid vaccine eliciting memory antibody response from single dose immunization. Patent application No. 1539/DEL/2011 dated 30.05.2011.
7. A Sortase-Click Reaction Suite for Defined Protein Dendrimer Assembly: Synthetic Example of a Multivalent Vaccine. Patent application No. 3113/DEL/2011 dated 01.11.2011.
8. Monoclonal antibody specific to hemagglutinin from influenza virus h1-subtype and uses thereof. Patent application No. 3799/DEL/2011 dated 23.12.2011.

Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram

1. A method for synthesis of dendrimer polymeric resins for Solid phase peptide synthesis, Indian Patent No. 248244 granted.
2. A Mouthwash Composition for Managing Oral Mucositis, Process and

Methods Thereof. Patent Application No. PCT/IB2011/054877 dated 03.11.2011.

Centre for DNA Finger Printing and Diagnostics, Hyderabad

1. A method of altering levels of plasmids. Indian Patent 246791, granted on 16.03.2011.
2. Virus resistant transgenic silkworms. Indian Patent filed on 4.06.2011.

National Centre for Cell Sciences, Pune

1. Creation of Artificial Bone-Marrow Environment and Uses Thereof: International patents have been filed in various countries. Granted and sealed in New Zealand.
2. Preservation of Human hematopoietic stem/progenitor cells using mannose binding lectins of plant origin. Indian patent sealed. International applications being defended by DBT

Translational Health Science and Technology Institute, Gurgaon

A method and device for detection of anti-transglutaminase antibodies. Patent filed Application No. 1133/DEL/2011

List of Patents filed/ granted under DBT funded projects during 2011-12

1. Silk protein blend film development and commercialization for burn wound management. Filed in India: Application No. 367/CHE/2007; filing date: 23/02/2007
2. Tissue engineering of homologous natural biomaterial for clinical use.
 - Filed in PCT: Application No. PCT/IN2008/000404; Filing date: 25/06/08 for small diameter vascular graft from processed cadaver cephalous vein and Application No. PCT/IN2008/000405; Filing date: 25/06/08 for Amniotic Membrane.
 - Filed in India: Application No. 2221/CHE/2007; Filing date: 25/06/08, (G.136) for Amniotic Membrane and Application No. 2222/CHE/2007; Filing date: 25/06/08 (G.137) for small diameter vascular graft from processed cadaver cephalous vein
3. Development of a platform for production of complex peptides and proteins, filed two patents in India:
 - Application No. 3211/MUM/2010; Title: Expression of complex proteins in yeast;

Purpose: To cover expression and production of recombinant human prethrombin in yeast and production of human thrombin.

- Application No. 3213/MUM/2010; Title: Yeast expression platform for expression of complex proteins and metabolites; Purpose: To cover the novel yeast expression platform developed by the company that overexpresses 3 chaperones, the overexpression of each of which can be controlled - leading to proper folding and high expression of target protein (Ex: Human Serum Albumin), in yeast.
- 4. Novel methods of isolation of biochemicals from crustacean exoskeleton. Filed in India: Application No. 1153/CHE/2008; Filing date: 16/10/08.
- 5. Design, synthesis, evaluation and development of the Novel H_3 and other GPC receptor ligands for various therapeutic applications. Filed in India: Application No. 3278/MUM/2011; Filing date: 23/11/2011.
- 6. Method for Production of Fermentable Sugars from Biomass", PCT Application No. PCT/IN2010/000355. Entered national phase in Australia, Brazil, Canada, China, EPO, Indonesia, Japan, Malaysia, Philippines, South Africa, South Korea, Srilanka, USA and Vietnam.
- 7. Continuous Countercurrent Fluidized Moving Bed (FMB) and/or Expanded Moving Bed (EMB), PCT Application No. PCT/IN2010/000133: Entered national phase in US, Korea, China, Canada and EPO.
- 8. Complete Specification filed for "A process for isolation of natural and bioactive proteins and other minor components from defatted oil seed materials" following provisional application No. 3577/MUM/2010.
- 9. Indian Patent Granted for "A Process for Purification of Immunoglobulins using a Pseudobioaffinity Adsorbent" Application No. 635/ MUM/ 2006; Granted Patent No. 248707, date of grant 9 August 2011.
- 10. Process for Fractionation of biomass; Application No: 1762/MUM/2010; PCT/ IN 2010/000634; Inventors: Lali, Arvind Mallinath; Varavadekar, Jayesh Suman; Wadekar, Prathamesh Chandrashekher.
- 11. A process for production of fermentable sugars from lignocellulosic substrates

- (Indian Patent: Application No. 1348/DEL/2011)
12. The Art, Method, Manner, Process and System of Chitosan hydrogel/Nano Zinc Oxide Membranes for Wound Dressing Applications. Indian Patent, File. No. 1025/CHE/2010, Date.12th April, 2010.
 13. Filed a provisional Indian patent- "organic fertilizer from degradation of raw chicken-feather by iron-oxide magnetic nanoparticle (mnp) bound â-keratinase". Application number 1416/kol/2011, dated 18.12.2010
 14. Indian patent filed: 0033nf2011dated 09-05-2011
 15. United States patent has been granted and the title of the project "A process for producing a bio-pesticide composition containing *Trichoderma harzianum* and *Pseudomonas fluorescens*" Patent No: US7,923,005B2
 16. A novel 2-3 dimensional fabrication technique of microchannels in soft polymers using soft lithography technique, Indian patent
 17. Integrated dielectrophoresis based rapid concentration of pathogenic bacteria and their quantitaion using Flourescence techniques, Indian Patent.
 18. Infectious DNA vaccines against chikungunya virus. US Patent Application Number: US2011/000001
 19. Consensus sequences of chikungunya viral proteins, nucleic acid molecules encoding the same, and compositions and methods for using the same PCT NO: PCT/US09/39656
 20. Anti-Chikungunya monoclonal antibodies and uses thereof. Patent application number: 20110143333

*Annexure-VII***List of Technologies developed/ transferred during 2011-2012**

International Centre for Genetic Engineering and Biotechnology, New Delhi

M/s. Genotypic technology Pvt. Ltd., Bangalore for the development of "Chickpea Expression Microarray".

1. Cry 1Ac & Vip 3A gene products developed for Insect Resistance transferred to Nagarajuna Fertilizers and Chemical Ltd. (MTA), India.

Medical Biotechnology: Infectious diseases

An immuno-chromatographic rapid visual test named "**Crystal TB confirm**" for detection of tubercle bacilli in culture developed at University of Delhi South Campus (UDSC).

2. Insulin - recombinant Gene product transferred to The United Laboratories, China

3. Recombinant Hepatitis B Surface Antigen - recombinant Gene Product transferred to The United Laboratories, China

Aquaculture & Marine Biotechnology

RT-PCR kit was developed for diagnosis of fish nodavirus.

National Institute on Plant Genome Research, New Delhi

Biodesign Programme

Next Generation Challenge Programme on Chickpea Genomics has generated whole chickpea transcriptome and transferred to

A faecal incontinence device has been developed under the Stanford-India Biodesign Programme.

ABBREVIATIONS

AAU	Assam Agricultural University
AcKA	Acetate Kinase
ACTREC	Advanced Centre for Treatment, Research and Education in Cancer
API	Active Pharmaceutical Ingredients
ARI	Agharkar Research Institute
ATM	ataxia-telangiectasiamutated
ATR	ATM and Rad 3-related
AVD	Abnormal vaginal discharge
BAC	Bacterial Artificial Chromosome
BBB	Blood brain barrier
BHU	Banaras Hindu University
BIBCOL	Bharat Immunologicals and Biologicals Corporation Ltd
BIF	Bifidobacteria
BIPP	Biotechnology Industry Partnership Programme
BIRAC	Biotechnology Industry Research & Development Assistance Council
BIRAP	Biotechnology Industry Research Assistance Programme
BMI	Body mass index
Bp	Base pair
BSL	Biosafety level
BT	Behavioural Therapy
BUILDER	Boost to University Inter disciplinary Life Science Departments for Education and Research Scheme
BY 2	Tobacco bright yellow cell line
CA	Controlled storage
Caco2	Colorectal adenocarcinoma cells
CARI	Central Avian Research Institute

CCMB	Centre for Cellular and Molecular Biology
CD4	Cluster of differentiation
CDFD	Centre for DNA Fingerprinting and Diagnostics
CDHA	Calcium deficient hydroxyapatite nanocarriers.
CDSA	Clinical development service agency
CEB	Centre for Energy Bioscience
CFU	Colony forming units
CHO	Chinese Hamster Ovarian cell line
CI	chymotrypsin inhibitory
CIBA	Central Institute of Brackishwater Aquaculture
CIFA	Central Institute of Freshwater Aquaculture
CIMAP	Central Institute of Medicinal and Aromatic Plants
CIPHET	Central Institute of Post Harvesting and Technology
CIRB	Central Institute for Research on Buffaloes
COE	Centres of Excellence
CPP's	Caseinophosphopeptides
CPPRI	Central Pulp & Paper Research Institute
CSFR	Cassava Starch Flour Residues
CSRTI	Central Sericultural Research & Training Institute
CSSRI	Central Soil Salinity Research Institute
CTAB	Cetyl Triethyl Ammonium Bromide
CTCRI	Central Tuber Crop Research Institute
CTEP	Conferences, Travel, Exhibitions and Popular Lectures
DFE	Dairy and Food processing Engineering
DNA	Deoxyribonucleic acid
DNAJB6	DnaJ homolog subfamily B member 6
DRR	Directorate of Rice Research
DU	Delhi University

E.coli	Escherichia coli
EBF	Early B cell factor
EhCaBP	<i>Entamoeba histolytica</i> calcium-binding protein
ELISA	Enzyme Linked Immunosorbant Assay
EPD	Electrophoretic deposition
EPN	Entomopathogenic Nematodes
ER α	Estrogen Receptors Alpha
ESE1	Epithelium-Specific ETS transcription factor-1
EST	expressed sequence tags;
ETS	Erythroblast Transformation Specific
FAME	Fatty Acid Methyl Ester
FCR	Feed Conversion Ratio
FFA	Free Fatty Acid
FPE	Food Processing engineering
FSH	Follicle Stimulating Hormone
FTIR	Fourier transformation infrared spectroscopy
FVM	Finite Volume method
GADVASU	Guru Angad Dev Veterinary and Animal Sciences University
GBPUAT	Govind Ballabh Pant University of Agriculture and Technology
GCSF	Granulocyte Colony Stimulating Factor
GL	<i>Ganoderma lucidum</i>
GMO	Genetically modified organisms
GNP	Gold Nanoparticles
GSI	Gonado Somatic Index
GST	Glutathione S- Transferase
GUS	beta-glucuronidase;
HAMP	Histidine kinases, Adenylyl cyclases, Methyl binding proteins, Phosphatases
h-BRCA1	Human Breast-Cancer-Associated Gene 1

hCG	Human chorionic gonadotropin
hGBPI	human Guanylate Binding Protein-1
HIV	Human Immuno Deficiency Virus
HPLC	High performance liquid chromatography
Hsp70	Heat Shock Protein 70
IARI	Indian Agriculture Research Institute
IAVI	International AIDS Vaccine Initiative
IBD	Inflammatory bowel disease
IBIN	Indian Bioresource Information Network
IBSD	Institute of Bioresources and Sustainable Development
IC	International Collaboration
IC50	Half maximal inhibitory concentration
ICAR	Indian Council of Agricultural Research
ICGEB	International Centre for Genetic and Engineering Biotechnology
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Institute of Chemical Technology, Mumbai
IDA	International Depository Authority
IF1, 2	Initiation Factor 1 and 2
IFN γ	Interferon-gamma
IGFRI	Indian Grassland and Fodder Research Institute
IGIB	Institute of Genomics and Integrative Biology
IHBT	Institute of Himalayan Bioresource Technology
IIAR	Indian Institute of Advanced Research
IICT	Indian Institute of Chemical Technology
IIHR	Indian Institute of Horticulture Research
IIMT	Indian Institute of Minerals Technology
IISc	Indian Institute of Sciences
IISER	Indian Institute of Science and Education Research

IIT	Indian Institute of Technology
IL-1	Interleukin-1
ILS	Institute of Life Sciences
INF α	Interferon-beta
INM	Integrated Nematode Management
iNOS	Inducible Nitric Oxide Synthase
InStem	Institute for Stem Cell Biology and Regenerative Medicine
IOCL	Indian Oil Corporation Limited
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
IU	International unit
IVCOL	Indian Vaccines Corporation Limited
IVRI	Indian Veterinary Research Institute
IVTD	In vitro true digestibility
IYBA	Innovative Young Biotechnologist Award
JNU	Jawaharlal Nehru University
LAB	Lactic acid bacillus
LDC	leprosy-derived corynebacteria
LEEP	Loop electrical excision procedure
LOI	Letter of intent
MAMC	Maulana Azad Medical College
MAP	Mitogen-activated protein
MCC	Microbial Culture Collection Centre
MCF 7	Breast cancer cell line and
MIRS	Multiple Insecticides Tolerant (resistant) Strain
MKU	Madurai Kamaraj University
mRNA	Messenger Ribo Nucleic Acid
MSSRF	MS Swaminathan Research Foundation

Mtb	Mycobacterium tuberculosis
MVC	Madras Veterinary College
N ₂ a	Neuroblastoma cell line,
NABI	National Agri-Food Biotechnology Institution
NARI	Nimbakar Agricultural Research Institute
NBAGR	National Bureau of Animal Genetic Resources
NBDB	National Bioresource Development Board
NBRC	National Brain Research Centre
NBRI	National Botanical Research Institute
NCBS	National Centre for Biological Sciences
NCCS	National Centre for Cell Sciences
NCI H 460	Lung cancer cell line
NCIM	National collection of industrial microorganisms
NCL	National Chemical Laboratory
NDRI	National Dairy Research Institute
NEERI	National Environmental Engineering Research Institute
NEHU	North East Hill University
NFkB	nuclear factor kappa-light-chain-enhancer of activated B cells
NGS	Next Generation Sequencing
NH	Nerve cell homing
NIAB	National Institute of Animal Biotechnology
NIBMG	National Institute of Biomedical Genomics
NII	National Institute of Immunology
NIIST	National Institute for Interdisciplinary Science and Technology
NIPGR	National Institute of Plant Genome Research
NIRRH	National Institute for Research in Reproductive Health
NLS	Nuclear Localization Signal
NMR	Nuclear magnetic resonance

NRC	National Research Centre
NRCPB	National Research Centre on Plant Biotechnology
NTFP	Non-timber Forest products
OMP	Outer Membrane Protein
OPV	Oral Polio Vaccine
ORT	Oral rehydration therapy
PaLCuV	Papaya leaf curl virus
PAT	Process Analytical Technology
PAU	Punjab Agriculture University
PCR	Polymerase chain reaction
PDA	Potato dextrose agar
PDP	Project Directorate on Poultry
PduW/TdcD	Propionate acetate kinase
PEO	Plasma Electrolytic oxidation
PGE2	Prostaglandin E
PGN	Peptidoglycan
PGPR	Plant Growth Promoting Rhizobacteria
PHA	Polyhydroxyalkanoate
PHE	Post harvest engineering
PI	Proteinase Inhibitory
PNA	Peptide nucleic acid
PPIases	Peptidylpropyl isomerases
q PCR	quantitative Polymer Chain Reaction
QTL	Quantitative Trait Locus
R&D	Research & Development
RAP80	Receptor Associated protein 80
RAPD	Random Amplification of Polymorphic DNA
RBD	Random Block Design; RNA: ribonucleic acid
RCGM	Review Committee on Genetic Manipulation

rDNA	recombinant deoxyribonucleic acid
RGCB	Rajiv Gandhi Centre for Biotechnology
RHD	Rheumatic Heart Disease
RIP	Receptor Interacting Protein
RNA	Ribonucleic Acid
RRF	Ribosome Recycling Factor
rRNA	Recombinant Ribonucleic Acid
RT- PCR	Real Time Polymerase Chain Reaction
SAM	Severe Acute Malnutrition
SAU	State Agricultural University
SBIRI	Small Business Innovation Research Initiative
SBRL	Seri Biotech Research Laboratory
SC	Schedule Caste
SD	Standard Deviation
SDS PAGE	Sodium Dodecyl Sulphate Polymerase Acryl Gel Electrophoresis
SGPGIMS	Sanjay Gandhi Post Graduate Institute of Medical Sciences
SHG	Self Help Group
SiRNA	Small Interfering RNA
SKUAST	Sher-e-Kashmir University of Agricultural Sciences & Technology
SL	Structures lipids
SLE	Systemic Lupus Erythematosus
SNB 19	Human Embryonic cells- Normal cells
SNP	Single-Nucleotide Polymorphism;
SRI	Systemic Rice Intensification
ST	Schedule Tribe
SVVU	Sri Venkateswara Veterinary University
TANUVAS	Tamil Nadu Veterinary and Animal Sciences University
TERI	The Energy and Resources Institute

THP-1	Human acute monocytic leukemia cell line
THSTI	Translational Health Science and Technology Institute
TI	Trypsin inhibitory
TNAU	Tamil Nadu Agriculture University
TNF α	Tumor Necrosis Factor alpha
UAS	University of Agricultural Sciences
UCS	University College of Science, Kolkata
UDSC	University of Delhi South Campus, New Delhi
UOH	University of Hyderabad
URL	Uniform Resource Locator
VIA	Visual Inspection by Acetic Acid
VMSRF	Vittal Malaya Scientific Research Foundation
WDCM	World Data Centre for Microorganism
WF	Weaning foods
WFCC	World Federation for Culture Collection
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WSSV	White Spot Syndrome Virus





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